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Accuracy and reliability of conodont zones: the *Polygnathus asymmetricus* "zone" and the Givetian-Frasnian boundary

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Abstract

Limestones from the top of the Bouia Formation, Tafilalt, south-eastern Morocco, that traverse the Givetian-Frasnian boundary (base of the Lower *P. asymmetricus* Zone) were sampled several times for conodonts. In the Bou Tchrafine section near Erfoud a styliolinid coquina bed 6 cm thick was sampled five times, in each case from the whole bed at the same place. The bed immediately below belongs to the *Klapperina disparilis* Zone and the overlying one to the Middle *P. asymmetricus* Zone. The conodont fauna from the styliolinid bed varies from one sample to another and has been attributed as follows: once to the upper part of the Lower *P. asymmetricus* Zone, once to the lower part? of the Lower *P. asymmetricus* Zone and three times to an interval covering the top of the *K. disparilis* Zone?, the entire Lowermost and the lower part? of the Lower *P. asymmetricus* Zone. There is no relationship between the stratigraphic accuracy obtained and the size of the sample. In two nearby outcrops, 300 m and 600 m to the southeast, the microcoquina is thicker (15 cm and 51 cm) and composite; each bed was sampled once or twice and the zonal attribution shows the same variation as in the first outcrop. The varying results from the consecutive samplings are explained not only by the depositional environment (a condensed limestone sequence) but also by the unsatisfactory definition of conodont zones between the *K. disparilis* Zone and the Middle *P. asymmetricus* Zone. It would be appropriate to revise that part of the standard conodont zonation on the basis of non-condensed sequences.

Résumé

Les calcaires du sommet de la Formation Bouia dans le Tafilalt, sud-est du Maroc, contenant la limite Givetien-Frasnien (base de la Zone à *P. asymmetricus* Inférieure) ont été échantillonnés à plusieurs reprises pour l'étude des Conodontes. Dans la coupe du Bou Tchrafine, près d'Erfoud, un banc coquillier à styliolinides, épais de 6 cm, a été prélevé cinq fois, dans chaque cas sur toute l'épaisseur du banc et au même endroit. Le banc immédiatement sous-jacent appartient à la Zone à *Klapperina disparilis* et celui sus-jacent à la Zone à *P. asymmetricus* Moyenne. La faune à Conodontes du banc à styliolinides varie d'un échantillon à l'autre et est attribuée comme suit: dans un cas à la partie supérieure de la Zone à *P. asymmetricus* Inférieure, dans un cas à la partie inférieure? de la Zone à *P. asymmetricus* Inférieure et dans trois cas à un intervalle comprenant le sommet de la Zone à *K. disparilis*?, l'entièreté de la Zone à *P. asymmetricus* la plus Inférieure et à la partie inférieure? de la Zone à *P. asymmetricus* Inférieure. Il n'y a pas de relation entre la précision stratigraphique obtenue et la quantité traitée de l'échantillon. Dans deux affleurements proches, à 300 m et à 600 m au sud-est du premier, le banc coquillier est plus épais (15 cm et 51 cm) et composite; chaque banc a été échantilloné une ou deux fois et l'attribution zonale montre la même variation que dans le premier affleurement. Les résultats variables obtenus à partir d'échantillonnages consécutifs sont expliqués non seulement par les conditions de dépôt (une séquence calcaire condensée) mais aussi par la définition insatisfaisante des zones à Conodontes entre la Zone à *K. disparilis* et la Zone à *P. asymmetricus* Moyenne. Il serait approprié de réviser cette partie de la zonation standard à Conodontes d'après l'étude de séquences non condensées.

Introduction

Most papers on conodont biostratigraphy do not mention whether the results were obtained from one or more samplings and if all the results from the successive samplings were consistent. The present paper deals mainly with an experiment in which the same beds from an identical section were sampled several times and processed separately. Especially for one bed the conodont fauna varies from one sampling to another and this leads to significantly different biostratigraphic interpretations. The results differ by as much as one or two zones or a subdivision of a zone. The cause of these consecutive samplings of one section was the 1982 decision of the Subcommission on Devonian Stratigraphy that the Middle-Upper Devonian boundary coincides with the earliest occurrence of the conodont *Ancyrodella rotundiloba* (BRYANT, 1921), which together with *Polygnathus asymmetricus* BISCHOFF and ZIEGLER, 1957, defines the base of the Lower *P. asymmetricus* Zone, and that the stratotype for this boundary be located in the pelagic facies. One of the candidate boundary stratotypes was the Bou Tchrafine ridge near Erfoud in the Tafilalt province of southeastern Morocco. The Middle-Upper Devonian boundary beds there contain a rich conodont, styliolinid and goniatite fauna. In the most complete section (BT I) in the Bou Tchrafine ridge, the Middle-Upper Devonian boundary beds were first sampled for conodonts in 1975 by BULTYNCK

and HOLLARD (1980) and afterwards in 1979 by BULTYNCK and JACOBS (1981). In 1981, 1983 and 1984 BENSAID, BULTYNCK, SARTENAER, WALLISER and ZIEGLER visited BT section I and also other potential candidate stratotypes in southeastern Morocco. On these various occasions the author resampled BT section I. Following discussion on the lateral continuity of some of the boundary beds from BT section I, SARTENAER suggested sampling other sections in the Bou Tchrafine ridge. Two other complementary sections were investigated, BT section II and BT section III, 300 m and 600 m to the southeast. Preliminary reports on the different candidate boundary stratotypes in southeastern Morocco were submitted by BENSAID, BULTYNCK, SARTENAER, WALLISER and ZIEGLER to the Subcommission on Devonian Stratigraphy during the Montpellier meeting (1983) and the Bristol meeting (1985).

Between 1978 - 1982 conodont zonation at the Middle-Upper Devonian boundary underwent several modifications. The stratigraphic ranges of some conodont species, *Klapperina disparilis* (ZIEGLER and KLAPPER, 1976) and *K. disparalvea* (ORR and KLAPPER, 1968), previously considered to be characteristic of the Lowermost *P. asymmetricus* Zone, were modified and the two species were removed from the above mentioned Zone. CHERNYSHEVA and KHALYMBADZHA (1977), KLAPPER and JOHNSON (1980), JOHNSON *et al.* (1980), BULTYNCK and HOLLARD (1980), BULTYNCK and JACOBS (1981) and ZIEGLER and KLAPPER (1982) introduced new formal or informal biostratigraphic units between the *S. hermanni - P. cristatus* Zone and the Lower *P. asymmetricus* Zone. HUDDLE (1981) and BULTYNCK (1982) proposed similar informal subdivisions for the Lower *P. asymmetricus* Zone. KLAPPER and FEIST (1985) use a new criterion for recognizing the base of the Lowermost *P. asymmetricus* Zone and they also describe a refined *Ancyrodella*-sequence within the Lower *P. asymmetricus* Zone.

The results are discussed first using the standard Devonian conodont zonation reviewed by KLAPPER and ZIEGLER (1979), with the addition of the *K. disparilis* Zone.

Representative specimens of all the listed species from the same area of Morocco are figured in BULTYNCK and HOLLARD (1980) and BULTYNCK and JACOBS (1981) or in the present paper.

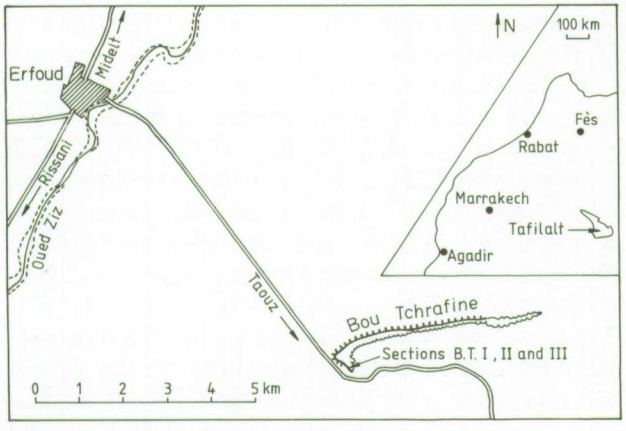


Fig. 1. – *Sketch map showing the Bou Tchrafine sections. Erfoud is situated in the northern Tafilalt, shown in the small index map of part of Morocco.*

Localisation, description and sampling of the sections

Near Erfoud limestones from the Bou Tchrafine Group (Eifelian-Givetian) and Achguig Group (Givetian-Famennian) form prominent ridges (HOLLARD, 1981). One of these is the Bou Tchrafine ridge, about 8 km SE of Erfoud, with a 5 km long E-W limb and an 800 m long NW-SE limb. The three investigated sections are along the latter limb.

BT section I is measured at exactly the same place as that described by BULTYNCK and HOLLARD (1980) and by BULTYNCK and JACOBS (1981). The BT section figured by ZIEGLER and KLAPPER (1982) is 24 m to the southeast and the thickness of beds is slightly different. In figure 2 only the Bouia Formation, lowest unit of the Achguig Group, and its contact with the underlying Bou Tchrafine Group are illustrated. The Middle-Upper Devonian boundary is probably between the unit with brownish-pink limestones (micritic mudstones and biomicritic or micritic wackestones) and the first overlying dark styliolinid coquina (biomicrosparitic grainstone), bed 37, 6 cm thick. This bed can easily be followed laterally and in BT section I it is separated from a second dark styliolinid coquina, bed 48, by three reddish — or greenish-grey limestone beds. According to BULTYNCK and JACOBS (1981) the second styliolinid coquina is within the Middle *P. asymmetricus* Zone.

The first styliolinid coquina has been sampled five times at the same place, samples 1975-37, 1979-44, 1981-37, 1983-37 and 1984-37. The sample size varies between 2 kg and 12 kg. The underlying and overlying beds were sampled twice or three times.

In the BT section II, 300 m to the southeast, the styliolinid coquina at the base of the third unit of the Bouia Formation is thicker (15 cm to 17 cm) and composite (beds 12, 13 and 14). It is assumed that these three beds correspond lithostratigraphically to bed 37 from BT section I. One bed, 13, is marly. The section was sampled once in 1983; sample weight was between 1 kg and 3 kg.

Section BT III is 300 m southeast of section II and nearly at the southeastern end of the Bou Tchrafine ridge. In figure 2 only the base of the third unit of

the Bouia Formation is represented. The first styliolinid coquina level is much thicker, 51 cm, and composite, comprising eight beds, two of which (3 and 4) are marls. It is assumed that the eight beds correspond lithostratigraphically to bed 37 of BT section I. The two basal beds were sampled twice, samples 1983-12a and 12b, 1984-1 and 2; the other beds were sampled once. Sample weight varied between 1 kg and 2 kg.

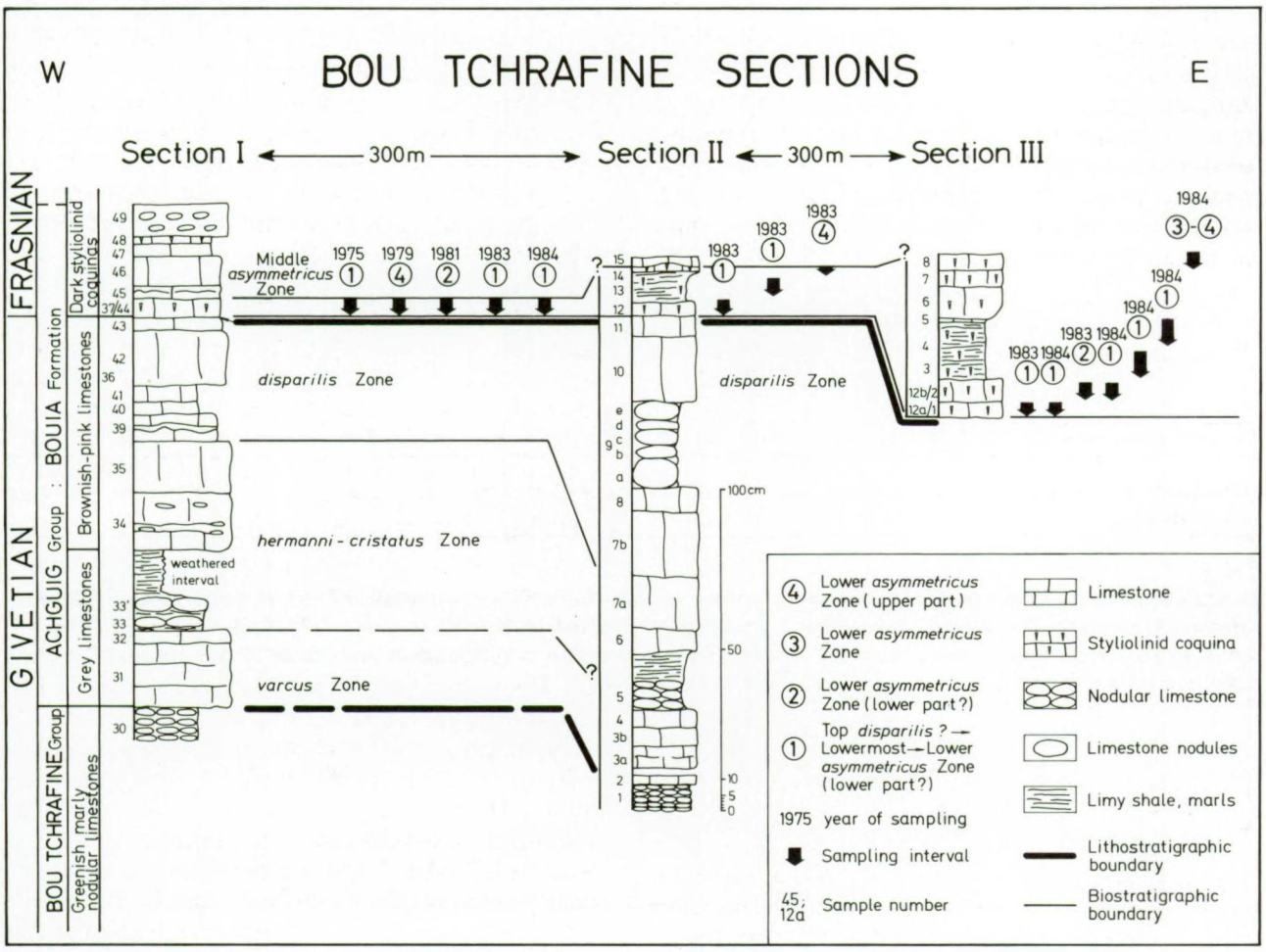
Conodont distribution and biostratigraphic attribution

Detailed distribution and frequency of conodont elements for the different samples is given in table I. Biostratigraphic interpretation of the consecutive samplings is shown in figure 2.

The brownish-pink limestones at the top of the second unit of the Bouia Formation (section I, beds 42 and 43; section II, bed 11) always clearly belong to the *K. disparilis* Zone. In BT section I the composition of the conodont fauna from the first styliolinid coquina varies from one sampling to another. The different constitution of the conodont faunas permits the five samples (1975-37; 1979-44; 1981-37; 1983-37; 1984-37) originating from the same bed to be assigned to three different biostratigraphic intervals, indicated by the numbers ①, ② and ④ in figure 2.

Interpretation ①: Top of the *K. disparilis* Zone? - Lowermost *P. asymmetricus* Zone - lower part? of the Lower *P. asymmetricus* Zone. The conodont fauna assigned to this biostratigraphic interval was obtained three times and is characterized by the first occurrence in the sequence of *Polygnathus pennatus* HINDE, 1879 and *Polygnathus norrisi* UYENO, 1967. The former species is relatively abundant, the latter common. *Polygnathus dengleri* BISCHOFF and ZIEGLER, 1957 and *Polygnathus ordinatus* BRYANT, 1921, known from the beds below are also common. The four species have never been found in the overlying bed 45, which is always dated as Middle *P. asymmetricus* Zone by the first occurrence of *Palmatolepis punctata* (HINDE, 1879). The fauna also contains rare specimens of *Polygnathus cristatus* HINDE, 1879 and very rare specimens questionably attributed to *P. asymmetricus*. *Icriodus subterminus* YOUNGQUIST, 1947 first occurs in these samples.

Fig. 2. – *Correlation of the three Bou Tchrafine sections.*



Conodont taxa	Section BT I										BT II				BT III						
Sampling year	1979	1979	1983	1975	1983	1984	1981	1979	1979	1983	1983	1983	1983	1983	1983	1984	1983	1984	1984	1984	1984
Sampling number	42	43	43	37	37	37	37	44	45	45	11	12	13	14	12a	1	12b	2	3	4-5	8
Schmidtognathus peracutus	A	R	C	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
Klapperina disparilis	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
disparalvea	C	-	P	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
Polygnathus caelatus	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
limitaris	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ovatinodosus	P	CC	C	-	-	-	-	-	-	-	P	P?	-	-	-	-	-	-	-	-	-
collieri	R	-	-	-	-	R	-	-	-	-	P	-	R	-	-	-	R	R	R	R	-
cristatus	R	-	-	-	R?	-	R	-	-	-	-	R	-	-	-	R	-	R	-	-	-
ordinatus	-	P	P	-	R?	R?	R	-	-	-	R	R?	-	-	-	P	R	-	-	R	-
dengleri	A	CC	A	R?	P	R	P	P	-	-	A	P	-	C	C	R	P	R	R	R	-
dubius	A	A	A	C	P	C	C	C	P	P	C	C	P	P	P	P	P	P	P	P	C
pollocki	CC	-	-	-	-	-	-	C	CC	CC	-	-	-	-	P	-	-	-	P	-	-
"varcus"	AA	-	AA	CC	R	C	CC	C	A	CC	-	CC	-	CC	A	C	CC	C	C	C	-
"rugosus"	-	P	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
dengleri → ovalis	-	R	-	-	-	R	-	-	-	-	R	-	-	R	R	R	-	R	-	-	-
ovalis	-	R	-	-	-	-	-	C	A	CC	-	-	-	C	R?	-	-	-	-	-	C
"decorosus"	-	-	CC	-	-	P	-	-	A	CC	-	-	-	C	CC	P	-	P	-	-	-
norrisi	-	-	-	P	R	P	P	-	-	-	-	P	R	-	C	P	P	R	R	P	-
pennatus	-	-	-	C	C	CC	CC	P	-	-	-	CC	P	-	C	-	C	C	C	C	-
angustidiscus	-	-	-	-	-	-	-	-	C	C	-	-	-	P	-	-	-	-	-	-	-
webbi	-	-	-	-	-	R	R	-	-	-	-	P	-	-	C	C	C	-	-	-	C
asymmetricus	-	-	-	R?	-	-	P?	P	P	P	-	-	R?	C	-	R?	-	-	-	-	P
unilabius	-	-	-	-	-	-	-	R	C	CC	-	-	-	-	-	-	-	-	-	-	C
sp. indet.	-	-	-	C	-	-	CC	-	-	-	-	-	P	-	-	-	-	-	-	-	-
Icriodus expansus	R	-	P	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
brevis-eslaensis group	R	-	-	C	-	-	C	-	-	-	-	P	-	-	P	R	P	P	P	-	-
difficilis	R	-	-	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-
latecarinatus	-	-	-	-	-	R	-	-	-	-	-	P	-	-	P	C	-	P	R	-	-
subterminus	-	-	-	C	R	R	P	-	-	-	-	P	-	-	P	R	-	-	-	P	-
symmetricus	-	-	-	-	-	-	-	R	CC	A	-	-	-	P	-	-	-	-	-	-	C
sp. indet.	P	P	-	C	-	R	C	P	-	-	-	CC	R	C	C	-	P	-	R	P	P
Ozarkodina sannemanni	P	P	P	R	R	R	R	R	P	P	P	P	-	-	P	-	P	R	-	P	-
gradata	-	R	-	-	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-	-
Ancyrodella rotundiloba	-	-	-	-	-	-	R?	R	-	-	-	-	-	C	-	-	R?	-	-	-	P
alata	-	-	-	-	-	-	-	P	-	-	-	-	-	C	-	-	-	-	-	-	-
africana	-	-	-	-	-	-	-	P	-	-	-	-	-	C	-	-	-	-	-	-	-
pramosica	-	-	-	-	-	-	-	A	R	R	-	-	-	CC	-	-	-	-	-	-	R
rugosa	-	-	-	-	-	-	-	-	-	-	-	-	-	CC	-	-	-	-	-	-	-
aff. *gigas*	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-
gigas	-	-	-	-	-	-	-	-	C	C	-	-	-	-	-	-	-	-	-	-	-
Palmatolepis transitans	-	-	-	-	-	-	-	-	P	P	-	-	-	P	-	-	-	-	-	-	-
punctata	-	-	-	-	-	-	-	-	C	C	-	-	-	-	-	-	-	-	-	-	-
proversa	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-
Bars and blades indet.	AA	AA	AA	C	P	CC	CC	A	AA	AA	AA	A	R	AA	AA	A	A	A	A	A	A
Total number of specimens	1000	402	668	104	27	122	199	262	746	628	270	228	20	499	350	250	158	150	103	151	250
Sample weight kg.	3	3	4	4,5	3	12	2	3	3	2,8	1	3	2	2	2	2	2	1,6	1	1	2

Table I.
Distribution and frequency of conodont elements for the Middle-Upper Devonian boundary beds in the three Bou Tchrafine sections. Frequency: R = rare (1-2 specimens); P = present (3-9 specimens); C =common (10-20 specimens); CC = very common (21-50 specimens); A = abundant (51-100 specimens); AA = very abundant (more than 100 specimens). Samples from one section between two bold lines are from the same bed.

According to ZIEGLER in KLAPPER and ZIEGLER (1979) *P. dengleri, P. ordinatus* and probably also *P. pennatus* do not range higher than the Lower *P. asymmetricus* Zone. UYENO (1967 and 1974), MOURAVIEFF (1977) and KLAPPER and JOHNSON (1980) mention *P. norrisi* from the Lowermost and the Lower *P. asymmetricus* Zones. The reason for considering the top of the *K. disparilis* Zone (with question mark) as a possible zonal attribution for the conodont fauna under discussion is based on the observation that in different areas *P. norrisi* enters slightly below *P. asymmetricus* (Canada, Northwest Territories, UYENO, 1979; France, Montagne Noire, FEIST and KLAPPER, 1985). JOHNSON *et al.*, 1985, restrict the range of *P. norrisi* to the Lowest and the base of the Lower *P. asymmetricus* Zone but without discussion. For this reason the top of the considered biostratigraphic interval is indicated as lower part? of the Lower *P. asymmetricus* Zone.

Interpretation ②: lower part? of the Lower *P. asymmetricus* Zone. This result was obtained once with sample 1981-37. Besides the conodont taxa characterizing interpretation ① this fauna also contains two broken *Ancyrodella* specimens with a small rhombic pit and without well developed secondary keels; they probably belong to *Ancyrodella rotundiloba,* marking the base of the Lower *P. asymmetricus* Zone. The mention of "lower part?" refers to the presence of *P. norrisi.* This more precise biostratigraphic interpretation was obtained with a smaller sample weight than interpretation ①, but the total number of recorded specimens was greater.

Interpretation ④: upper part of the Lower *P. asymmetricus* Zone. The result was obtained once with sample 1979-44. Of the four stratigraphically relevant *Polygnathus* species, *P. pennatus, P. dengleri, P. ordinatus* and *P. norrisi,* present in the previously discussed samples from bed 37, the two last are missing. Stratigraphically significant first occurring species for this sample are *P. asymmetricus, P. unilabius* HUDDLE, 1981, *A. rotundiloba, A. alata* GLENNISTER and KLAPPER, 1966, *A. africana,* GARCIA-LOPEZ, 1981 and *A. pramosica* PERRI and SPALETTA, 1981. The first three *Ancyrodella* species are rare to common, the last is abundant. According to HUDDLE (1981), BULTYNCK (1982) and FEIST and KLAPPER (1985) the three last *Ancyrodella* species permit the overall conodont fauna to be placed in the upper part of the Lower *P. asymmetricus* Zone. *Icriodus symmetricus* BRANSON and MEHL, 1934, is also confined to this sampling. This is the most precise biostratigraphic result obtained from the numerous samplings of the first styliolinid coquina in BT section I; it is also based on the highest number of conodont specimens recorded in sampling this bed.

BT Section II

Sample 1983-12 at the base of the styliolinid coquina produced a rich conodont fauna that corresponds almost exactly to interpretation ① obtained from 3 samples of bed 37 in BT section I. *P. asymmetricus* is absent and bed 11 directly below belongs to the *K. disparilis* Zone. Sample 1983-13 from the marly part of the styliolinid coquina immediately above bed 12 contained only a small conodont fauna with *P. norrisi, P. pennatus, P. collieri* HUDDLE, 1981 and one questionable specimen of *P. asymmetricus.* This fauna is also assigned to biostratigraphic interval ①. The conodont fauna from sample 1983-14 at the top of the lower level with styliolinid coquinas is very similar to that from sample 1979-44 in BT section I. Additional taxa in the present fauna are *Ancyrodella rugosa* BRANSON and MEHL, 1934, *Ancyrodella* aff. *A. gigas* YOUNGQUIST, 1947 and *Palmatolepis transitans* MÜLLER, 1956. They do not modify the proposed biostratigraphic range of interpretation ④: upper part of the Lower *P. asymmetricus* Zone.

BT Section III

In this section the lower level with styliolinid coquinas is the thickest. Five samples, 1983-12a, 1984-1, 1984-2, 1984-3 and 1984-4+5 produced conodont faunas corresponding with interpretation ① obtained for bed 37 in BT section I. Sample 1983-12b originating from the same bed as sample 1984-2 contains, in addition to *P. dengleri, P. norrisi, P. ordinatus* and *P. pennatus* one questionable specimen of *Ancyrodella rotundiloba.* Interpretation ② is adopted for this sample. *P. asymmetricus, P. unilabius, P. ovalis* ZIEGLER and KLAPPER, 1964, *A. rotundiloba* and *I. symmetricus* are the most common species in sample 1984-8 at the top of the lower level with styliolinid coquinas in section III. The most suitable biostratigraphic attribution for such a fauna is Lower *P. asymmetricus* Zone (interpretation ③ in figure 2). The presence of one specimen of *A. pramosica* in this sample may justify an assignment to the upper part of the Lower *P. asymmetricus* Zone (interpretation ④).

Discussion

The main problem is the partial inconsistency of the various results obtained by successive samplings of bed 37 from BT section I. The differences concern the conodont frequency (from 9 to 100 specimens/kg) and the distinct specific constitution of the conodont faunas. The latter fact leads to three different biostratigraphic interpretations. They are not necessarily contradictory but at least their degree of accuracy is different. Inaccuracy and contamination during the sampling and processing are excluded here to explain the different results.

Bed 37 is lithologically distinct from the underlying and overlying beds; it is thin and was sampled five times over its total thickness and at the same place. Stratigraphically significant species from the underlying bed (*K. disparilis, K. disparalvea* and *Schmidtognathus peracutus* BRYANT, 1921 and the overlying bed (*A. gigas, P. punctata*) have never been found in samples from bed 37. On the other hand some species common in bed 37 were never present in samples from the underlying bed (*P. pennatus, P. norrisi*) and the overlying bed (*P. pennatus, P. norrisi, P. ordinatus, P. dengleri, A. rotundiloba, A. alata*).

Differences between the results from the successive samplings of bed 37 are explained here by:

1. — the special sedimentary circumstances, involving a condensed limestone sequence deposited on a submarine high in the basinal area as described by BULTYNCK and JACOBS (1981);
2. — the unsatisfactory definition of conodont zonation between the *K. disparilis* Zone and the Middle *P. asymmetricus* Zone, more specifically the Lowermost *P. asymmetricus* Zone and the Lower *P. asymmetricus* Zone with informal subdivisions on the basis of *Ancyrodella* species.

The three distinct biostratigraphic results are not necessarily inconsistent. This is certainly true in the case of interpretation ① (top *K. disparilis* Zone? - Lowermost *P. asymmetricus* Zone - lower part? of Lower *P. asymmetricus* Zone) and ② (lower part? of Lower *P. asymmetricus* Zone), the second interpretation being more precise than the first. This is explained by the much higher conodont frequency (100 specimens/kg) for sample 1981-37 in comparison to the frequency in the three samples from bed 37 providing the interpretation ① (9 to 23 specimens/kg). Nevertheless there is no clear relationship between the conodont frequency and the size of the sample (see table I). This indicates an irregular distribution of the conodonts in bed 37.

There is some contradiction between interpretation ④ and interpretations ① and ② for the same bed. *Ancyrodella alata, A. pramosica* and *A. africana,* which characterize interpretation ④, have never been found to occur, here or in other sections in other areas, with *P. norrisi,* one of the common species for interpretations ① and ②. This may be due to a stratigraphic condensation of two conodont faunas of different age within bed 37. The main part of this bed belongs to the lower part of the *P. asymmetricus* Zone and the upper part of the same Zone is only represented patchily at the top of the bed. This interpretation is supported by investigation of sections BT II and III where the styliolinid coquina of bed 37 is thicker and composite. In these two sections interpretations ① and ② are always confined to the lower part of the styliolinid coquina and result ④ to the top above the marly part.

The original concept of the Lowermost and of the Lower *P. asymmetricus* Zones and the informal subdivision of the latter, to a certain degree, may lead to conflicting biostratigraphic interpretations as encountered here. Before discussing this point two characteristics of zonal fossils should be kept in mind: reasonable abundance and small vertical range (DONOVAN, 1966). Reasonable abundance of a species should not be seen only as the number of specimens in one sample but also as the number of samples in which the species occur.

ZIEGLER (1971) introduced the Lowermost *P. asymmetricus* Zone for "the lowest part of the former Lower *asymmetricus* Zone" (ZIEGLER, 1962). "The Lowermost *asymmetricus* Zone coincides with the occurrence of *P. asymmetricus* before *Ancyrodella rotundiloba* appears". He also emended the former Lower *P. asymmetricus* Zone: "it is based on the joint occurrences of *P. asymmetricus* and *A. rotundilona* before the first appearance of *P. punctata*".

According to the original definition of both zones, and bearing in mind the above mentioned characteristics of zonal fossils, *P. asymmetricus* should be reasonably abundant for identifying both zones. Many authors, in describing Middle-Upper Devonian conodont successions from different areas in both the neritic and the pelagic facies, noticed the irregular, rare occurrence of *P. asymmetricus,* or even its complete absence, in strata just below the entrance of *A. rotundiloba* and within the earliest range of *A. rotundiloba:* COEN (1973), MOURAVIEFF (1974), BULTYNCK and HOLLARD (1980), KLAPPER and JOHNSON (1980), HUDDLE (1981), BULTYNCK and JACOBS (1981), BULTYNCK (1982) and FEIST and KLAPPER (1985). This is also the case for the three BT section where the earliest common occurrence of *P. asymmetricus* is in samples with *A. alata* or *A. pramosica.* The fact that KLAPPER and JOHNSON (1980) introduced the *Polygnathus dengleri* Zone for the interval between the *hermani-cristatus* Zone and the Lower *P. asymmetricus* Zone, that BULTYNCK and HOLLARD (1980) used a *P. dengleri* Fauna and an *A. binodosa* Fauna for the same biostratigraphic interval, that HUDDLE (1981) suggested that the Zones between the *P. varcus* Zone and the *A. rotundiloba* Zone needs a new name as well as new definition, that ZIEGLER and KLAPPER (1982) defined a *K. disparilis* Zone and that FEIST and KLAPPER (1985) "for an operational definition" propose to use the lowest occurrence of *P. norrisi* to "identify the Lowermost *asymmetricus* Zone in the Montagne Noire sections, that lack the low occurrences of *P. asymmetricus*" clearly demonstrates that the earliest occurrence of *P. asymmetricus* is not accurate and reliable enough to define formally a standard conodont zone. Consequently it may not be necessary to distinguish a Lowermost *asymmetricus* Zone between the

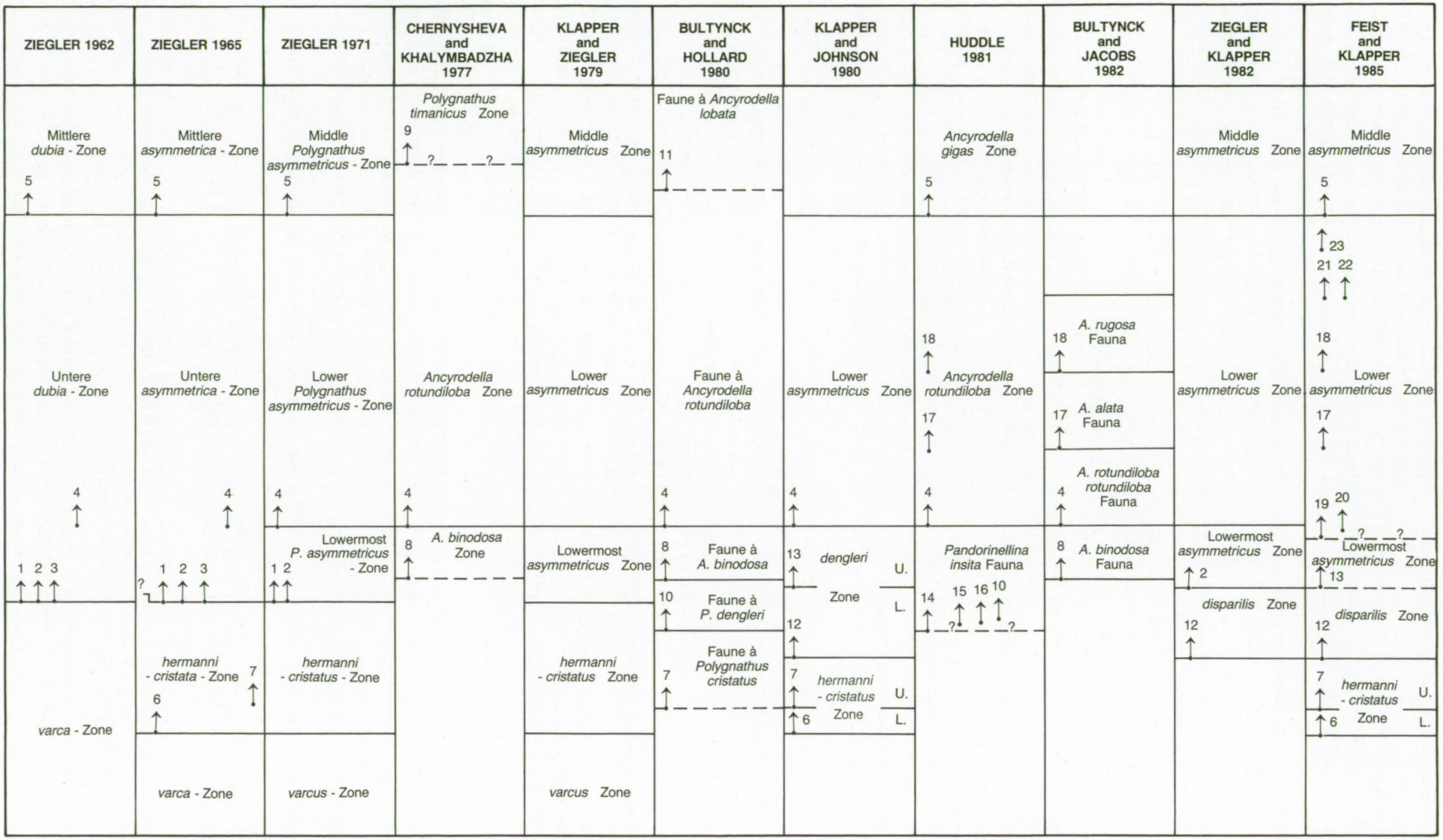


Fig. 3. – *Comparison of different late Givetian - early Frasnian conodont zonations.*
↑: *lower boundary of zone, subzone or informal subdivision defined by the lowest occurrence of 1.* Polygnathus ovalis (=P. dubia dubia), *2.* P. asymmetricus (=P. dubia asymmetrica), *3.* Palmatolepis transitans; *4.* Ancyrodella rotundiloba; *5.* Palmatolepis punctata (= P. martenbergensis); *6.* Schmidtognathus hermanni *7.* Polygnathus cristatus; *8.* Ancyrodella binodosa; *9.* Polygnathus timanicus; *10.* P. dengleri; *11.* Ancyrodella lobata; *12.* Klapperina disparilis; *13.* Polygnathus norrisi; *14.* Klapperina disparalvea; *15.* Schmidtognathus peracutus; *16.* Polygnathus pennatus; *17.* Ancyrodella alata; *18.* A. rugosa; *19. early form of* A. rotundiloba; *20. late form of* A. rotundiloba; *21.* A. africana; *22.* A. pramosica; *23.* A. gigas.

K. disparilis Zone and the Lower *asymmetricus* Zone.

In the emended definition of the Lower *asymmetricus* Zone by ZIEGLER (1971), mainly based on investigations of condensed limestone sequences in the Rhenish Slate Mountains, *A. rotundiloba* and *A. alata* have the same vertical range and ZIEGLER *in* KLAPPER and ZIEGLER (1979) maintains the same ranges. It is not strictly necessary to make, as here, a distinction between the interpretations ②, ③ and ④. On the other hand it is clear from the study of Lower Frasnian conodont successions in the neritic facies and in uncondensed pelagic facies by HUDDLE (1981) in New York, by BULTYNCK (1982) in the Ardennes, and by FEIST and KLAPPER (1985) and KLAPPER (1985) in the Montagne Noire, that *Ancyrodella alata, A. rugosa, A. pramosica* and *A. africana* provide a solid basis for subdividion of the Lower *P. asymmetricus* Zone. It is surprising that these species, which have proved to be accurate and reliable for biostratigraphic correlation, are not used to define formal zones or subzones. The reason may be the tendancy to preserve well known zonal names, but, the recommandation of the International Stratigraphic Guide edited by HEDBERG (1976, p. 64) state that: "In the case of biostratigraphic units, it must be kept in mind that ... not necessarily the first to be described and named but the most useful should be preserved. This means that workers must continually be free to propose new zones or improve previous proposals in both scope and nomenclature".

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PLATE I

All magnifications are × 50.

Figs. 1, 2. – Polygnathus pollocki *DRUCE, 1976. Section BT I, sample 1983-45. Lateral and upper views of I.R.Sc.N.B. n° b 1774 and n° b 1775.*

Fig. 3. – Polygnathus "varcus" *STAUFFER, 1940. Section BT I, sample 1979-45. Upper view of I.R.Sc.N.B. n° b 1776.*

Fig. 4. – Polygnathus pennatus *HINDE, 1879. Section BT I, sample 1984-37. Upper view of I.R.Sc.N.B. n° b 1777.*

Fig. 5. – Polygnathus norrisi *UYENO, 1967. Section BT I, sample 1984-37. Upper view of I.R.Sc.N.B. n° b 1778.*

Fig. 6. – Polygnathus collieri *HUDDLE, 1981. Section BT I, sample 1984-37. Upper view of I.R.Sc.N.B. n° b 1779.*

Figs. 7, 8. – Ancyrodella rugosa *BRANSON and MEHL, 1934. Section BT II, sample 1983-14. 7, Upper view of specimen I.R.Sc.N.B. n° b 1780. 8, Upper view of I.R.Sc.N.B. n° b 1781, secondary keels somewhat atypical.*

Figs. 9, 12. – Ancyrodella rotundiloba *(BRYANT, 1921). 9, section BT III, sample 1984-8. Upper view of I.R.Sc.N.B. n° b 1782, specimen somewhat atypical; no secondary keels present on the lower surface. 12a,b, section BT I, sample 1979-44. Upper and lower view of I.R.Sc.N.B. n° b 1783, blade missing.*

Figs. 10, 11. – Ancyrodella alata *GLENNISTER and KLAPPER, 1966. Section BT I, sample 1979-44. Lower and upper views of I.R.Sc.N.B. n° b 1784 and n° b 1785.*

Fig. 13. – Polygnathus rugosus *sensu ZIEGLER, 1965. Section BT I, sample 1983-1. Upper view of I.R.Sc.N.B. n° b 1786.*

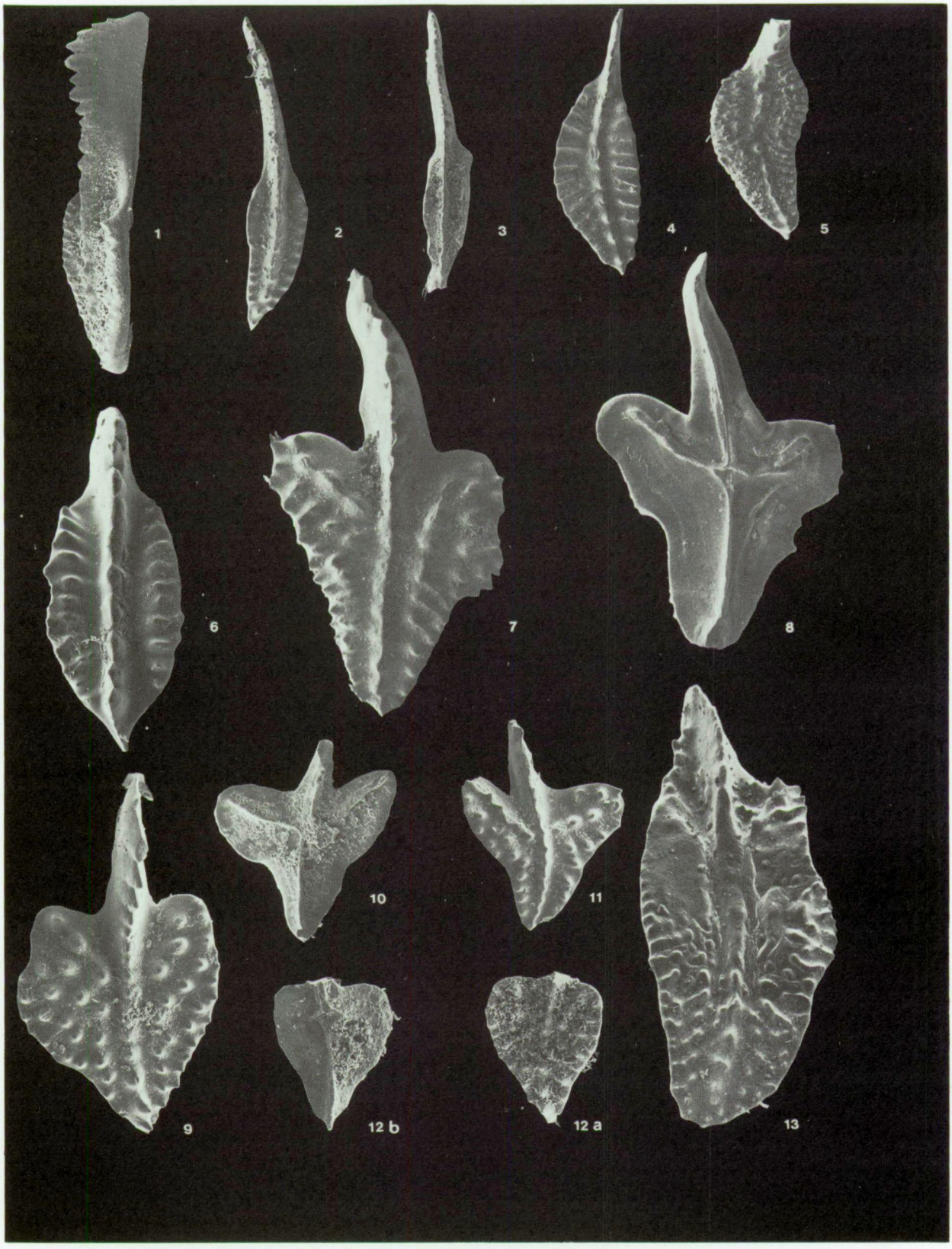
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PLATE II

All magnifications are × 50, except figs. 4b, 6b, 7b, 9b, 10b × 150, figs. 1b × 250.

Figs. 1, 2. – Polygnathus asymmetricus *BISCHOFF and ZIEGLER, 1957. Section BT II, sample 1983-14. 1a, lower view of I.R.Sc.N.B. n° b 1787; 1b, detail of pit from the same specimen; 2, upper view of I.R.Sc.N.B. n° b 1788.*

Fig. 3. – Polygnathus dengleri *BISCHOFF and ZIEGLER, 1957* → Polygnathus ovalis *ZIEGLER and KLAPPER, 1964. Section BT II, sample 1983-14. Upper view of I.R.Sc.N.B. n° b 1789.*

Figs. 4-6, 8, 9. – Polygnathus ovalis *ZIEGLER and KLAPPER, 1964. 4, 5, section BT II, sample 1983-14; 6, 8, 9, section BT I, sample 1983-45; 4a, lower view of I.R.Sc.N.B. n° b 1790; 4b, detail of pit from the same specimen; 5, upper view of I.R.Sc.N.B. n° b 1791; 6a, lower view of I.R.Sc.N.B. n° b 1792; 6b, detail of pit from the same specimen; 8, upper view of I.R.Sc.N.B. n° b 1793; 9a, lower view of I.R.Sc.N.B. n° b 1794; 9b, detail of pit from the same specimen.*

Figs. 7, 10-12. – Polygnathus unilabius *HUDDLE, 1981. 7, 11, section BT I, sample 1979-45; 10, 12, section BT I, sample 1983-45; 7a, lower view of I.R.Sc.N.B. n° b 1795; 7b, detail of pit from the same specimen; 10a, lower view of I.R.Sc.N.B. n° b 1796; 10b, detail of pit from the same specimen; 11, 12, upper views of I.R.Sc.N.B. n° b 1797 and n° b 1798.*

Figs. 13-14. – Icriodus subterminus *YOUNGQUIST, 1947. Section BT II, sample 1983-12. Lateral and upper views of I.R.Sc.N.B. n° b 1799 and n° b 1800.*

References

BULTYNCK, P. and HOLLARD, H., 1980. Distribution comparée de Conodontes et Goniatites dévoniens des plaines du Dra, du Ma'der et du Tafilalt (Maroc). *Aardkundige Mededelingen,* 1, 73 p.

BULTYNCK, P. and JACOBS, L., 1981. Conodontes et sédimentologie des couches de passage du Givetien au Frasnien dans le Nord du Tafilalt et dans le Ma'der (Maroc présaharien). *Bulletin Institut royal des Sciences naturelles de Belgique,* 53, 2, 1-24.

BULTYNCK, P. with contributions by JACOBS, L., 1982. Conodont succession and general faunal distribution across the Givetian-Frasnian boundary beds in the type area. *Papers on the Frasnian-Givetian boundary.* Geological Survey of Belgium, Brussels, 34-59.

CHERNYSHEVA, N.G. and KHALYMBADZHA, V.G., 1977. Zonalnoe rastschlenie verkhnedevonskikh otlojenii Volgo-Uralskoi oblasti po konodontam. *Stratigrafia i paleontologia Paleozoia vostoka Russkoi Platformy,* Kazan, 173-181.

COEN, M., 1973. Faciès, conodontes et stratigraphie du Frasnien de l'Est de la Belgique pour servir à une révision de l'étage. *Annales de la Société Géologique de Belgique,* 95, 239-253.

DONOVAN, D.T., 1966. Stratigraphy, an introduction to principles. Murby, London, 199 p.

FEIST, R. and KLAPPER, G., 1985. Stratigraphy and conodonts in pelagic sequences across the middle-upper Devonian boundary, Montagne Noire, France. *Palaeontographica,* 188, 1-18.

HEDBERG, H.D., 1976. International stratigraphic guide — A guide to stratigraphic classification, terminology and procedure. Wiley-Interscience Publication, New York, 200 p.

HOLLARD, H., 1981. Principaux caractères des formations dévoniennes de l'Anti-Atlas. *Notes Service Géologique du Maroc,* 42, 308, 15-23.

HUDDLE, J.W., 1981. Conodonts from the Genesee Formation in Western New-York. *Geological Survey Professional Paper* 1032-B, 66 p.

JOHNSON, J.G., KLAPPER, G. and TROJAN, W.R., 1980. Brachiopod and conodont successions in the Devonian of the northern Antelope Range, central Nevada. *Geologica et Palaeontologica,* 14, 77-116.

JOHNSON, J.G., KLAPPER, G. and SANDBERG, C.A., 1985. Devonian eustatic fluctuations in Euramerica. *Geological Society of America Bulletin,* 96, 567-587.

KLAPPER, G. and ZIEGLER, W., 1979. Devonian conodont biostratigraphy. *Special papers in Paleontology,* 23, 199-224.

KLAPPER, G. and JOHNSON, J.G., 1980. Endemism and dispersal of Devonian conodonts. *Journal of Palaeontology,* 24, 2, 400-455.

KLAPPER, G., 1985. Sequence in conodont genus *Ancyrodella* in lower *Asymmetricus* zone (earliest Frasnian, Upper Devonian) of the Montagne Noire, France. *Palaeontographica,* 188, 19-34.

MOURAVIEFF, N.A., 1974. Excursion F. *In* Guidebook International Symposium on Belgian micropalaeontological limits from Emsian to Visean. Namur 1974. Geological Survey of Belgium, Brussels, 11 p.

MOURAVIEFF, N.A., 1977. Additional conodonts from near the Middle-Upper Devonian boundary in North Cornwall; a progress report. *Proceedings of the Ussher Society,* 4, 1, 63-66.

UYENO, T.T., 1967. Conodont zonation, Waterways Formation (Upper Devonian), Northeastern and Central Alberta. *Geological Survey of Canada,* paper 67-30, 21 p.

UYENO, T.T., 1978. Devonian conodont biostratigraphy of Powell creek and adjacent areas, Western district of Mackenzie. *Geological Association of Canada Special Paper,* 18, 233-257.

ZIEGLER, W., 1962. Taxionomie und Phylogenie Oberdevonischer Conodonten und ihre stratigraphische Bedeutung. *Abhandlungen des Hessischen Landesamtes für Bodenforschung,* 38, 166 p.

ZIEGLER, W., 1965. Eine Verfeinerung der Conodontengliederung an der Grenze Mittel-/Oberdevon. *Fortschritte in der Geologie von Rheinland und Westfalen,* 9, 647-676.

ZIEGLER, W., 1971. Conodont Stratigraphy of the European Devonian. *Geological Society of America, Memoir,* 127, 227-284.

ZIEGLER, W. and KLAPPER, G., 1982. The *disparilis* conodont zone, the proposed level for the Middle-Upper Devonian Boundary. *Courier Forschungsinstitut Senckenberg,* 55, 463-492.

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