Pelagic and neritic conodont successions from the Givetian of pre-Sahara Morocco and the Ardennes

by Pierre BULTYNCK

Abstract

The present paper deals with conodont faunas ranging from the kockelianus Zone (late Eifelian) almost to the top of the Upper varcus Subzone (late Givetian). In the Ardennes, the conodont succession is primarily based on sections in the type area of the Givet Limestone, a 400 m thick sequence of mainly shallow water platform carbonates. Conodont faunas are dominated by species of Icriodus and Eognathodus. Species of Ozarkodina and Polygnathus are rare and in general their frequency is too low to ensure precise vertical ranges. Consequently, a direct and accurate correlation with the Eifelian-Givetian standard conodont zonation, established in the pelagic facies and based on species of Polygnathus, is difficult to establish. An alternative Icriodus zonation is proposed. In the Tafiilalt (pre-Sahara of Morocco), the zonal succession is established in the Bou Tchrafine section near Erfoud in the middle and upper part of the Bou Tchrafine Group and the base of the Bouia Formation, a 17 m thick condensed cephalopod limestone sequence belonging to the pelagic realm. Species of Polygnathus are particularly abundant; species of Icriodus occur but their general distribution is more irregular. The standard conodont zones are recognized, although a refinement of the zonation is proposed. In the Ma'der three sections in the NW part of the Issimour arch are studied. The sequence, 240 m thick, extends from the Taboumakhlouf Formation into the Middle Member of the Bou Dib Formation. Sediments and fauna reflect a neritic shelf environment. Conodont faunas are generally dominated by species of Polygnathus although species of Icriodus occur regularly and may be abundant. The conodont standard zonation and the alternative Icriodus zonation are both partially recognized in the same beds. The lowest occurrence of Polygnathus hemiansatus n. sp. within the ensensis Zone recognized in four sections from pre-Sahara Morocco and also in the Cantabrian Mountains (Spain) and in the Guangxi Province (South China) is considered here as a good potential level for the Eifelian-Givetian boundary. Three new species of Icriodus are described: I. platyobliquimarginatus, I. lilliputensis and I. obesus. Key-words: Biostratigraphy, Conodonts, Givetian, Ardennes, pre-Sahara Morocco.

Résumé

La présente contribution concerne des faunes à Conodontes observées de la Zone à kockelianus (fin de l’Eifelien) jusque près du sommet de la Sous-Zone à varcus Supérieure (fin du Givetien). Dans les Ardennes, la succession à Conodontes est principalement établie d’après l’étude de coupes situées dans la région-type du Calcaire de Givet, séquence épaisse de 400 m et surtout formée de carbonates déposés en milieu de plate-forme peu profonde. Les faunes à Conodontes sont dominées par des espèces d’Icriodus et d’Eognathodus. Les espèces d’Ozarkodina et de Polygnathus sont rares et leurs trop faibles fréquences ne permettent généralement pas d’établir avec exactitude les extensions stratigraphiques. Par conséquent, une corrélation directe et précise avec la zonation standard à Polygnathus établie dans le facies pelagique est difficile à établir. Une zonation parallèle à Icriodus est proposée. Dans le Tafiilalt (Maroc pré-saharien), la succession des zones est établie dans la coupe de Bou Tchrafine, près d’Erfoud, dans les parties moyenne et supérieure du Groupe de Bou Tchrafine et à la base de la Formation de Bouia; cette sequence condensée de calcaires à Céphalopodes est épaisse de 17 m et appartient au domaine pelagique. Les espèces de Polygnathus sont spécialement abondantes; les espèces d’Icriodus sont présentes mais leur distribution est généralement plus irrégulière. Les zones classiques à Conodontes sont reconnues bien qu’une subdivision plus détaillée soit proposée. Dans le Ma’der, trois coupes sont étudiées dans la partie NW d’Issimour. La séquence, épaisse de 240 m, est étendue de la Formation de Taboumakhlouf jusqu’au Membre Moyen de la Formation de Bou Dib. Les sédiments et la faune reflètent un environnement neritique de plate-forme. Les faunes à Conodontes sont généralement dominées par des espèces de Polygnathus bien que les espèces d’Icriodus soient régulièrement présentes et puissent être abondantes. La zonation standard à Conodontes et la zonation parallèle à Icriodus sont toutes deux partiellement reconnues dans les mêmes bancs. La première apparition de Polygnathus hemiansatus n. sp. dans la Zone à ensensis est établie dans quatre coupes du Maroc pré-saharien et est aussi reconnue dans les Monts Cantabriques, en Espagne, et dans la Province de Guangxi, en Chine méridionale; ce niveau biostratigraphique offre de bonnes possibilités de corrélation en ce qui concerne la limite Eifelien-Givetien. Trois nouvelles espèces d’Icriodus sont fondées: I. platyobliquimarginatus, I. lilliputensis et I. obesus. Mots-clefs: Biostratigraphie, Conodontes, Givetien, Ardennes, Maroc pré-saharien.

I. - Introduction

This paper provides new data on Eifelian-Givetian conodont successions, from the kockelianus Zone up to the Upper varcus Subzone, in new and previously described sections in the southeastern pre-Sahara of Morocco (BULTYNCK & HOLLARD, 1980; BULTYNCK & JACOBS, 1981; BULTYNCK, 1985) and from the type area of the Givet Limestone in the Belgian-French Ardennes. Eifelian and Givetian conodont faunas from the latter region have been studied in BULTYNCK (1972, 1974, 1976), BULTYNCK & GODEFROID (1974) and COEN, BULTYNCK & PEL (1974).
Comparison between the conodont successions from the two areas illustrates the difficulties encountered when correlating sections with different conodont biofacies. During the Givetian shallow water platform carbonate deposits predominated over a large part of the world. In these deposits mainly Icriodontidae occur, while the critical Polygnathus species of the standard zonation, in the present case the ensensis and varcus Zones, are absent or very rare. This is particularly true for the Givetian of the type area form which an alternative Icriodus zonation, proposed here, is the most accurate and useful tool. This Icriodus zonation is correlated with the standard zonation and with a refined Polygnathus succession recognized in the Eifelian-Givetian sections from Morocco with a deeper neritic or pelagic facies. This succession is conceived as a regional improvement of the standard zonation. Reasons for this and the modifications can be summarized as follows. BULTYNCK & HOLLARD (1980, p. 42) recognized in the Bou Tchrafine section (Tafilalt) a form Polygnathus aff. P. ansatus that enters 1.85 m above the top of the kockelianus Zone and below the first occurrence of P. timorensis, which defines the base of the varcus Zone. Klapper & Johnson (1980, p. 413) considered this form to be identical to P. ansatus, the first occurrence of which characterizes the base of the Middle varcus Subzone. According to this synonymy the ensensis Zone and the Lower varcus Subzone would be missing or represented in the 1.85 m unsampled interval. Sampling of this interval and restudy of BULTYNCK'S & HOLLARD's (1980) collections confirm the differences between P. ansatus and P. aff. P. ansatus, described herein as P. hemiansatus n. sp. This species is identified in other Moroccan sections and outside Morocco and its earliest occurrence is used to subdivide the ensensis Zone into two subzones.

BULTYNCK & HOLLARD (1980, p. 47) also proposed replacement of the varcus Zone, with its threefold subdivision, by four zones. WEDDGE (1984, p. 185) suggested comparable nomenclatorial modifications for the varcus Zone. Huddle (1981) drew attention to the difficulty in using the varcus Zone in western New York, due in part to the scarcity of the species. That P. varcus is rare in the western New York succession can also be concluded from the conodont distribution tables in ZIEGLER, KLAPPER & JOHNSON (1974, tabl. 1-4), where the species is recorded from only one sample in one section. Therefore, although the subdivisions of the varcus Zone are mentioned in

Fig. 1. – Sketch map showing the Mont d’Haur’s sections at Givet. Inset map shows location of Givet.
figures 2, 4 and 6 for reasons of common usage, a more precise regional zonation for this biostratigraphical interval is given in figure 9.

II. - Sections and their conodont successions

II-1. Ardennes Sections Mont d’Hauls and Fromelennes

(France IGN Mapsheet Givet XXX-7)

(Figs. 1-2)

The conodont results derive mainly from the succession at Mont d’Hauls, an old fortification on the east side of the Meuse at Givet, where the top of the Hanonet Formation (late Eifelian) and the two lower formations of the Givet Group, the Trois-Fontaines and the Mont d’Hauls Formations, are exposed. Seventy-five 3 to 6 kg samples have been processed. Conodont samples from Mont d’Hauls mentioned in Bultynck (1972) and in Coen, Bultynck & Pel (1974) have been incorporated in the sample succession on figure 2. The succession at Mont d’Hauls is established on the basis of six sections (Fig. 1, A to F). The distribution of the samples according to these sections is given in the locality and sample index. Data for the top of the Mont d’Hauls Formation and the lower part of the Fromelennes Formation are based on sampling of the section at Fromelennes by Bultynck (1974). I use the lithostratigraphic subdivisions established by Sartenaer & Errera, in Errera, Mamat & Sartenaer (1972) with the single exception that the base of the Mont d’Hauls Formation is drawn at the base of phase 10 and not at the base of phase 8. In the same paper (1972) Errera & Mamat recognized thirty-one sedimentary major phases (Fig. 2, column B) representing an alternation of open marine fore-reef deposits with reef deposits (coral and stromatoporoid biostromes) and back-reef deposits, the last two of which largely dominate in the succession. All the conodont samples have been located with reference to these phases. Conodont faunas are generally sparse, most commonly about 5 up to 20 specimens/kg, rarely more than 20/kg, and in only two samples more than 100/kg. The most productive samples are from phases 7, 8 and 9 just below the Mont d’Hauls Formation and from the basal part of the Fromelennes Formation; each case involves an open marine fore-reef environment with calcareous shales, carbonated nodules and argillaceous and silty limestones. The macrofauna includes brachiopods, tabulate and rugose corals, and trilobites. Samples from the back-reef environment, sample 17 to 24 and above sample 62, were barren. The conodont faunas are dominated by Icriodus taxa and Eognathodus bipennatus bipennatus in the Trois-Fontaines Formation, and by Icriodus taxa in the Mont d’Hauls and the Fromelennes Formation. Apart from a few samples from the basal part of the Fromelennes Formation, Polygnathus species are rare. For this reason the boundaries of the conodont standard zones, in the present case the ensensis Zone and the varcus Zone with its subdivisions, cannot be identified with precision. Using Polygnathidae it can be demonstrated directly that the basal 5 m of the Givet Limestone belong to the ensensis Zone. The eponymous zonal species has not been found in the Mont d’Hauls sections, but occurs 47 m below the base of the Givet Limestone in the Hanonet Formation at Couvin, 25 km west of Givet (recorded as Polygnathus xyla in Bultynck, 1970, Pl. XV, Fig. 2). The presence of Tortodus intermedius and Ozarkodina bidentata, known to disappear below the top of the ensensis Zone demonstrates that the basal 5 m of the Givet Limestone at Givet are still within the ensensis Zone. The first Polygnathus taxon indicative of the varcus Zone, P. xylus xylus, occurs 92 m above this level; P. timorensis, the first occurrence of which normally defines the base of the varcus Zone, appears much later, in the middle part of the Mont d’Hauls Formation. Specimens from samples 59 to 62, 220 m above the base of the Givet Limestone, belong to a brief open-marine incursion (phase 13) within a thick biostrome/back-reef sequence. There is also some evidence for the base of the Middle varcus Subzone in the lower part of the Fromelennes Formation. This interpretation is based on the last occurrence of P. pseudofolius and the first occurrence of specimens close to P. ansatus (see Pl. 8, Fig. 9). The Upper varcus Subzone and the hermanni-cristatus Zone were not recognized higher in the Fromelennes Formation, and the upper part of this formation was assigned to the Upper dengleri Subzone by Bultynck & Jacobs (1982, p. 36).

Distribution of Icrioids in the Givet Limestone is much more regular and at some levels they are abundant. In the Trois-Fontaines Formation, the Mont d’Hauls Formation and the lower part of the Fromelennes Formation eleven Icriodus taxa occur, three of which are new: I. platyobliquimarginatus, I. lilliputensis and I. obesus. The most important stratigraphically are I. regularicrescens, I. obliquimarginatus, I. lindenisis and I. brevis. These probably belong to one phylogenetic lineage and have a wide regional distribution in W. Europe, N. Africa and N. America (pars). Three new Icriodus zones, regularicrescens, obliquimarginatus and brevis, are established, the base of each zone being defined by the earliest occurrence of the zonal index. The three zones cover the kockelianus Zone, the ensensis Zone and part of the lower varcus Subzone. The earliest occurrence of I. lindenisis divides the obliquimarginatus Zone into lower and upper subzones.

The earliest occurrence of I. obliquimarginatus was used by Ziegler (1971, p. 24) to characterize the obliquimarginatus Zone, abandoned since 1976. The species is present in the top of the Hanonet Formation.
Fig. 2. - Conodont distribution and frequency in the Mont d’Haur sections and in the lower part of the Fromelennes section. Column A: lithostratigraphy, group and formations; B: sedimentary major phases after ERRERA & MAMET in ERRERA, MAMET & SARTENAER (1972); C: columnar section and conodont sample numbers; D: distribution and frequency of conodont taxa; E: conodont standard zonation; F: alternative Icriodus zonation.
Conodont successions Givetian Morocco Ardennes

ABBREVIATIONS AND SYMBOLS FOR FIGURES.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
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<tbody>
<tr>
<td>Limestone</td>
<td>Biostromal limestone (tabulate and rugose corals, stromatoporoids)</td>
</tr>
<tr>
<td>Marly limestone</td>
<td>Limestone nodules</td>
</tr>
<tr>
<td>Dolomitic limestone</td>
<td>Nodular limestone</td>
</tr>
<tr>
<td>Chert</td>
<td>Liny shale, marls</td>
</tr>
</tbody>
</table>

Occurrence and frequency of conodont taxa:

- ♦ earliest occurrence
- ♣ latest occurrence
- ♣ known from older strata
- ♣ known from younger strata
- ❓ questionable occurrence

at Mont d’H Frs, 4 m below the base of the Givet Limestone, although this is certainly not the earliest record for the type area. In other sections, for example Wella - Fond des Vaux 5 (BULTYNCK & GODDEFROID, 1974, p. 30, between samples 14 and 22), 24 km east of Givet, and Marenne (COEN, BULTYNCK & PEL, 1974, p. 13, sample 1), 45 km northeast of Givet, I. obliquimarginatus occurs respectively 16 m and 13 m below beds with the brachiopod Undispirifer givefex STRUVE, 1981, characteristic of the base of the Givet Limestone in the Ardennes.

II-2. Tafilalt Section Bou Tchrafine
(Morocco Mapsheet Erfoud NH-30-XX-2)
(Figs. 3-4)

A typical Eifelian-Givetian succession in the pelagic facies is exposed in the Bou Tchrafine section near Erfoud in the southern Tafilalt. The top of the Eifelian and most of the Givetian are represented by 17 m of cephalopod limestone, belonging to the Bou Tchrafine Group and subdivided into four formations by HOL LARD (1981). Goniatites and conodonts from this part of the section were discussed by BULTYNCK & HOL LARD (1980). In the present paper the conodont results are completed, especially in the Eifelian-Givetian boundary interval, where eight supplementary samples were taken from about 3 m of strata, between samples 14 and 16 of the 1980 study. The goniatite succession will be refined by WALLISER (University of Göttingen). Conodont frequency in the Eifelian and Givetian samples from the Bou Tchrafine section is good, most samples containing 50 to 100 specimens/kg. Species of Polygnathus, particularly in the P. linguiformis group, are abundant and diversified; species of Icriodus occur also in most of the samples but their frequency is irregular and species diversity is low. The standard conodont zones, kockelianus Zone, ensensis Zone and varcus Zone with original subdivisions, can be recognized, although some refinement is proposed. This includes the subdivision of the kockelianus Zone and the ensensis Zone into lower and upper subzones and the replacement of the varcus Zone of ZIEGLER, KLAPPER & JOHNSON (1976) by four zones, in ascending order: timorensis, rhenanus-varcus, ansatus, and semialternans-latifossatus Zones. The most characte-
### Chart:

**Eifelian**  
<table>
<thead>
<tr>
<th>BOU</th>
<th>TCHAFAINE</th>
<th>ACHGUIG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talus médian</td>
<td>Corniche supérieure</td>
<td>Couverture de la Corniche</td>
</tr>
<tr>
<td>Mince</td>
<td>Bouia</td>
<td></td>
</tr>
</tbody>
</table>

#### Polygnathus
- angusticostatus
- angustipennatus
- linguiformis linguiformis
- parawebbi
- pseudofoliatus
- trigonius
- robusticostatus
- eiflius
- pseudofoliatus ensensis
- linguiformis klapperi
- hemiansatus n. sp.
- ensensis — timorensis
- timorensis
- denisbriceae
- linguiformis weddigi
- xylus
- linguiformis transversus
- rhenanus
- varcus
- linguiformis mucronatus
- ansatus
- beckmanni
- rhenanus — semialternans
- semialternans
- latifossatus

#### Tortodus
- kockelianus kockelianus
- intermedius
- variabilis

#### Icriodus
- struver
- regularicrescens
- obliquimarginatus
- platyobliquimarginatus n. sp.
- obliquimarginatus
- lindensis
- brevis
dificilis

#### Belodelia
- kockelianus ensensis
- Lower
- varcus
- Middle
- varcus + varcus
- Upper

#### Other Species
- regularicrescens
- obliquimarginatus
- brevis
dificilis
ristic features of the conodont succession are summarized as follows.

1. - The entry of *P. eiflius* (sample 14a) is used to define the base of the Upper *kockelianus* Subzone.

2. - There is a clear faunal break between samples 15+ and 15bis. Six species common in Eifelian strata below have their last occurrence in bed 15+ or 15a, 15 cm below: *P. angusticostatus*, *P. angustipennatus*, *P. trigonius*, *P. robusticostatus*, *Tortodus kockelianus kockelianus* and *T. intermedius*. It should be stressed that there is no clear lithological break at this level. Typical specimens of *P. ensensis* occur from sample 15bis upwards; one questionable specimen was found in sample 15a.  

3. - *P. hemiansatus* n. sp. appears within the *ensensis* Zone (sample 15ter). BULTYNCK & HOLLAND (1980) and BULTYNCK (1985) identified specimens now assigned to the new species as *P. aff. P. ansatus* or as "early morphotype of *P. ansatus*" (see systematic part). *P. hemiansatus* is found in the same stratigraphic position in three Moroccan sections: Ma'der, Akka Bou Khedach, discussed here below; Ouahlane (BULTYNCK, 1985, Fig. 10, sample 27); and Jbel Ou Driss (HOLLAND, 1981, sample ODE 6). I identified the new species in material from Guangxi Province, South China, in sample 407 from the Sihongshan section described by ZIEGLER & WANG (1985); a specimen is figured on Plate 8, Fig. 5. Specimens from the Portilla Formation in the Cantabrian Mountains (Spain) identified by GARCIA-LOPEZ (1987, Pl. 11, Fig. 23; Pl. 12, Figs. 1-6, 9) as *P. ansatus* belong to *P. hemiansatus*. The lowest occurrence of *P. hemiansatus* is proposed here to define the base of the Upper *ensensis* Subzone.  

4. - The base of the (Lower) varcus Subzone, according to the definition of ZIEGLER, KLAPPER & JOHNSON (1976), is recognized by the first occurrence of *P. timorensis* in sample 18. It corresponds with the base of the *timorensis* Zone of the present paper.  

5. - *P. rhenanus* and *P. varcus* first occur in sample 23. Some authors consider *P. rhenanus* as a junior synonym of *P. timorensis* but they are separated in the present study (see systematic part). In different Moroccan sections *P. rhenanus* and *P. varcus* appear distinctly later than *P. timorensis*. Therefore that part of the Lower varcus Subzone with *P. timorensis* and before the entry of *P. rhenanus* and *P. varcus* is defined here as the *timorensis* Zone; the joint occurrence of *P. rhenanus* and *P. varcus*, which precedes the first appearance of *P. ansatus*, defines the *rhenanus-varcus* Zone.  

6. - *P. ansatus* is known first in sample 28; this level corresponds to the base of the Middle varcus Subzone of ZIEGLER, KLAPPER & JOHNSON (1976), named *ansatus* Zone in the present paper. In the Bou Tchrafine section occur three "pumilio", beds, which are coquina beds containing small terebratulids. Similar strata are well known from the Rheinisches Schiefergebirge and constitute the so-called "pumilio" Event of LOTT-MANN, SANDBERG, SCHINDLER, WALLISER & ZIEGLER (1986). In the Bou Tchrafine section the lowest "pumilio" bed (sample 26) is within the *rhenanus-varcus* Zone (= upper part of Lower varcus Subzone); the two upper "pumilio" beds (between sample 27 and 28, and sample 28) are at the base of the *ansatus* Zone (= Middle varcus Zone).  

7. - Polygnathus semialternans and specimens transitional between *P. semialternans* and *P. latifossatus* occur first in sample 32. This level corresponds closely to the base of the Upper varcus Subzone of ZIEGLER, KLAPPER & JOHNSON (1976) and is named *semialternans-latifossatus* Zone in the present paper.  

8. - The I. *regularicrescens*, I. *obliquimarginatus* and I. *brevis* Zones, established in the Eifelian and Givetian sequence of the Ardennes, are recognized in the Bou Tchrafine section. This Icriodus zonation is completed here with the I. *difficilis* Zone, the base of which is defined by the earliest occurrence of the nominal species. In the Bou Tchrafine section the base of the *obliquimarginatus* Zone coincides with the entry of *P. hemiansatus*. In the Givet Limestone, as noted earlier, the entry of I. *obliquimarginatus* is the most reliable first appearance that is closest to the base of this unit, and the provisional positioning of the Eifelian-Givetian boundary in the Bou Tchrafine section is based on the correlation with this biostratigraphic level.

II-3. Ma'der Sections Akka Bou Khedach, Taboumakhlouf Terrasse and Taboumakhlouf South (Morocco Mapsheet Missis NH-30-XX-1) (Pl. 1-3 and Figs. 5, 6, 7)
In the Ma’der area, about 100 km SW from Erfoud, three sections in the NW part of the Issimour arch, Akka Bou Khedach (ABK), Taboumakhlouf Terrasse (TT) and Taboumakhlouf South (TS), constitute a complete uppermost Eifelian-Givetian succession. The sequence, about 240 m thick, extends from the Taboumakhlouf Formation into the Middle Member of the Bou Dib Formation (HOLLARD, 1974 and 1981). The lithology, described by HOLLARD (1974, pp. 49-56), and the macrofauna, mainly brachiopods, corals at some levels and sparcely occurring goniatites, reflect a deeper shelf environment.

Fig. 5. – Geological sketch map of the Ma’der showing the five sections referred to in the text (modified from HOLLARD, 1974, Fig. 1); location of more detailed map (Fig. 6) shown by small rectangle with sections ABK, TT and TS. Inset map of part of Morocco shows location of the Ma’der.

Fig. 6. – Sketch map of the NW part of the Issimour arch showing the position of measured sections Akka Bou Khedach (ABK), Taboumakhlouf Terrasse (TT) and Taboumakhlouf South; detail of Ma’der map (Fig. 5).
Conodont frequency is a little lower than in the Bou Tchrafine section and varies between about 20 and 100 specimens/kg. *Polygnathus* species are dominant, although not so abundant as in the Bou Tchrafine section. *Icriodus* species occur regularly and are abundant at some levels.

The conodont standard zonation from the *kockelianus* Zone into the Upper *varcus* Subzone is partially recognized. It proved impossible to separate the Lower from the Middle *varcus* Subzone and the base of the Upper *varcus* Subzone is indicated approximatively by the earliest occurrence of *P. semialternans*. Of the three new critical entries of *Polygnathus* species in the Bou Tchrafine section, two occur at the same stratigraphic position: *P. hemiansatus* in sample ABK 6, and *P. rhenanus* together with *P. varcus* in sample ABK 1. The alternative *Icriodus* zonation is also recognized.
III. Systematic Palaeontology

Representatives of taxa mentioned in the range charts (Figs. 2, 4, 7, 9) are figured in plates 4-9 and in figure 8. *Eognathodus bipennatus bipennatus*, *Icriodus brevis*, *I. eslaensis*, *I. excavatus*, *I. lindensis*, *I. obliquimarginatus*, *I. aff. I. arkonensis*, *Polygnathus ansatus*, *P. ensensis*, *P. rhenanus*, *P. semialternans* and *P. timorenensis* are discussed below. *Icriodus lilliputensis* n. sp., *I. obesus* n. sp., *I. platyobliquimarginatus* n. sp. and *Polygnathus hemiansatus* n. sp. are established. All remarks and descriptions refer to Pa elements.

**Genus Eognathodus Philip, 1965**

*Eognathodus bipennatus bipennatus* (BlSchoff & ZlEGLER, 1957) (Plate 9, Figures 1-10)

* 1957 *Spathognathodus bipennatus* n. sp. — BlSSCHOFF & ZlEGLER, pp. 115-116, Pl. 21, Fig. 31.

Remarks:
The upper side of the platform of the holotype of *E. bipennatus bipennatus* is characterized by a relatively well developed medial groove or dépression extending from just behind the high convex blade almost to the posterior end. On both sides the dépression is flanked by a row of low nodes or transversal ridges. I distinguish two morphotypes of *E. bipennatus bipennatus*. In the alpha morphotype (Pl. 9, Figs. 1-5) the medial groove is relatively narrow, does not extend so far posteriorly as in the holotype and is flanked on both sides by a smooth or weakly nodose ridge. The beta morphotype (Pl. 9, Figs. 8-10) is very similar to the holotype. However, the beta morphotype includes specimens with a much broader medial dépression than in the holotype. In the Mont d’Haurs section the alpha morphotype appears earlier than the beta morphotype. The angle between the anterior margins and the lower margin can be slightly sharp, right of slightly obtuse, contrary to the opinion of WEDDIGE (1977).

**Genus Icriodus branson & mehl, 1938**

*Icriodus brevis* stauffer, 1940 (Plate 6, Figures 1-14)

* 1940 *Icriodus brevis* n. sp. — STAUFFER, p. 424, pl. 60, figs. 9, 10, 12; 11?

Remarks:
The denticulation pattern on the spindle of *Icriodus brevis*, *I. eslaensis* and *I. lindensis* is identical: the medial-row and lateral-row denticles are discrete and of equal size with a tendency to alternation; in the medial row denticles can be intercalated. The extension of the medial-row denticles posterior of the spindle is relatively long: 3 to 5 denticles. The three species can be distinguished on the basis of the outline of the posterior extension in lateral view. In *I. brevis* the denticles of this posterior extension are not markedly higher than the denticles on the spindle, the general outline of the extension is slightly fan-shaped, the highest denticle being at mid-length. The cusp is inclined and generally wider than the other denticles of the extension. For differences with *I. eslaensis* and *I. lindensis*: see below under the discussion of these species.

*Icriodus eslaensis* van adrichem boogaert, 1967 (Figure 8, a-f)

* 1967 *Icriodus eslaensis* n. sp. — VAN ADRICHEM BOO-GAERT, pp. 180-181, figs. 9, 10, 12; 11?

Remarks:
There is much confusion about the status of this taxon. According to SEDDON (1970), the types of this species belong to *I. obliquimarginatus*. KLAPPER in ZlEGLER (1975, ed.) considers the taxon synonymous with *I. brevis* and WEDDIGE (1977) includes one of the primary types of *I. eslaensis* in *I. lindensis*. After a restudy of the figured types and additional material from the sample containing the holotype that is figured here I consider the taxon as valid. It can be separated from *I. brevis* and *I. lindensis* by the outline of the posterior extension of the medial-row denticles behind the spindle. The first denticles of the posterior extension, 2 to 4, are relatively small, the cusp behind is markedly higher and wider. See also under *I. brevis* and *I. lindensis*.

*Icriodus excavatus* WEDDIGE, 1984 (Plate 6, Figures 21-25)

* 1984 *Icriodus excavatus* n. sp. — WEDDIGE, p. 208, pl. 1, figs. 9-22.

Remarks:
In his diagnosis of *I. excavatus*, WEDDIGE (1984) mentions that there is not always a medial depression in the posterior part of the spindle. The figured type material of *I. excavatus* can be subdivided into a more slender morphotype on the one hand to which the holotype and four paratypes (Pl. 1, Figs. 10-13) all from the sample Da16 belong — and a broad strongly biconvex morphotype (Pl. 1, Figs. 15-22) from a series of samples from another locality on the other hand. Specimens from the Givet Limestone assigned to *I. excavatus* all belong to the first morphotype and the middle-row denticles always lie in a depression in the
posterior part of the spindle. In the Givet Limestone occur also specimens similar to the broad biconvex morphotype. However, these specimens never have a depression in the posterior part of the spindle. Therefore they are not included in I. excavatus and described below as a new species I. obesus. Previously, BULTYNCK (1972 and 1979) figured these forms as Icriodus n. sp. a assemblage and I. aff. I. subterminus. WEDDIEGE (1977) included them in I. subterminus; the same author (1984) assigned them to I. excavatus. See also under I. obesus.

*Icriodus lindensis* WEDDIGE, 1977
(Plate 4, Figures 17-22)

1972 *Icriodus eslaensis* assemblage — BULTYNCK, p. 81, partim, figs. 14, A, E, F.

Remarks:
The spindle of *I. lindensis* is slightly biconvex. The 3 to 4 denticles of the posterior extension of the middle row increase regularly in height. The cusp is a little higher and wider than the other denticles and slightly to strongly reclined. In representative specimens of *I. lindensis* the posterior extension of the middle row is slightly curved in upper view. See also under *I. brevis* and *I. eslaensis*.

*Icriodus lilliputensis* n. sp.
(Plate 5, Figures 13-19)


*Derivatio nominis:*
*Lilliputensis*, from Lilliput, referring to the small size of the species.

*Types:*
Holotype. I.R.Sc.N.B. N° b1893 (= Pl. 5, Fig. 14).

*Locus typicus:*
Givet (France), Mont d’Haurs, section D.

Fig. 8. — *Icriodus eslaensis* VAN ADRICHEM BOOGAERT 1967 (× 120) a-d, f: upper and oblique-lateral views of RGM383192-2, -1 and -4; Rio Esla area, Cantabrian mountains (Spain), sample IV-C-74 in VAN ADRICHEM BOOGAERT (1967), stratum typicum of *I. eslaensis*; specimens preserved at Rijksmuseum van Geologie en Mineralogie, Leiden (The Netherlands). e: upper view of I.R.Sc.N.B. N° b1857; sample Mont d’Haurs 53.
Stratum typicum:
Givet Group, Trois Fontaines Formation, phase 7, sample 27.

Diagnosis:
Spindle short with biconvex or triangular outline. Four to five pairs of rounded to slightly oval-shaped lateral-row denticles on spindle and five to six rounded medial-row denticles. Medial-row denticles may be connected by a longitudinal ridge and they are at the same height as the lateral-row denticles. High and straight anterior rim in lateral view and with prominent denticle. Posterior extension of medial row with two to four fused denticles and not markedly higher than the other denticles. Cusp slightly inclined. Basal cavity moderately expanded in the posterior half of the unit and with a weak or prominent spur.

Remarks:
* I. lilliputensis is similar to I. subterminus. However, in the latter species the denticles of the middle row are lower than those of the lateral rows and the denticles of the posterior extension of the middle row are abruptly and much higher than the others.

Icriodus obesus n. sp.
(Plate 6, Figures 15-20)

1972 Icriodus n. sp. a assemblage — BULTYNCK, p. 82, figs. 16, A-E.
1979 Icriodus aff. I. subterminus — BULTYNCK in BRICE et al., p. 334, pl. 27, figs. 28, 29, 32.

Derivatio nominis:
Obesus, Latin, fat, referring to the strongly biconvex outline of the spindle.

Types:
Holotype. I.R.Sc.N.B. N° bl913 (= PI. 6, Fig. 15). Paratypes. I.R.Sc.N.B. N° b1914, N° b1915, N° b1916, N° b1917, N° b1918 (= PI. 6, Figs. 16-20).

Locus typicus:
Givet (France), Mond d’Haurs, section D.

Stratum typicum:
Givet Group, Mont d’Haurs Formation, phase 11, sample 50.

Diagnosis:
Spindle thick-set and strongly biconvex, upper surface flat. Four to six pairs of rounded to oval-shaped lateral-row denticles, usually slightly smaller. Lateral-row denticles well spaced. Short and broad posterior extension of medial row with two or three fused denticles and at the same level as the other denticles on the spindle. Nearly symmetrical and very broadly expanded basal cavity; expansion starting near the anterior termination; weak spur may be present.

Remarks:
* I. obesus is similar to I. amabilis BULTYNCK & HOLLARD, 1980. However, specimens of the latter species have the posterior half of the middle row set higher than the lateral rows and the expanded part of the basal cavity is much more posteriorly located.

In I. excavatus the basal cavity is markedly asymmetric and the medial-row denticles lie in a depression in the posterior part of the spindle. The variation of I. excavatus also includes more slender morphotypes. See also under I. excavatus.

Icriodus obliquimarginatus
BISCHOFF & ZIEGLER, 1957
(Plate 4, Figures 7-10, 12-16)


Remarks:
Most specimens assigned here to I. obliquimarginatus perfectly demonstrate the diagnostic features mentioned in the emended diagnosis of WEDDIGE (1977). In the present study typical specimens of I. obliquimarginatus are restricted to the upper part of the ensensis Zone and the lower part of the Lower varcus Subzone. Below the range of I. obliquimarginatus, Icriodus specimens occur, which are very similar to I. obliquimarginatus. However, they differ from the latter by the high posterior cusp and the straight posterior extension of the medial row. Such specimens, figured by BULTYNCK (1970, Pl. 8, Figs. 2, 4, 7, 8) were included by WEDDIGE (1977) in I. obliquimarginatus. They are considered here as transitional forms between I. regularicrescens and I. obliquimarginatus. In most specimens recorded from the neritic shallow water facies (Givet Limestone) the denticles on the spindle are discrete, whereas specimens from the pelagic facies (Bou Tchrafine Group) develop irregular transversal ridges on the spindle. See also under I. platyobliquimarginatus.

Icriodus platyobliquimarginatus n. sp.
(Plate 5, Figures 1-9)

1970 Icriodus obliquimarginatus BISCHOFF & ZIEGLER — BULTYNCK, pp. 109-110, partim, pl. 8, figs. 1, 5; non pl. 8, fig. 3 = I. obliquimarginatus.
1972 Icriodus aff. I. obliquimarginatus assemblage — BULTYNCK, p. 81, figs. 13, C, D.

Derivatio nominis:
Platys, from πλατυς, Greek, broad + obliquimarginatus, referring to the broad spindle and the similarity to I. obliquimarginatus.
Types:
Holotype. I.R.Sc.N.B. N° b1881 (= Pl. 5, Fig. 2).

Locus typicus:
Menil (Belgium), section described in COEN, BULTYNCK & PEL (1974, pp. 14-16).

Stratum typicum:

Diagnosis:
Rather robust form. Spindle broad, with triangular to slightly biconvex outline, widest posteriorly. Four to five pairs of transversely expanded and well-spaced lateral-row denticles on spindle and five to seven rounded to elongate medial-row denticles, slightly smaller than the lateral-row denticles. Medial-row denticles mostly connected by a longitudinal ridge that reaches the anterior termination. Posterior extension of the middle row with four to seven denticles and with arcuate profile, highest medially and with moderately to strongly reclined posterior border. Nearly symmetrical basal cavity, broadly expanded posteriorly.

Remarks:
I. platyobliquimarginatus is distinguished from I. obliquimarginatus by possessing a distinctly broader spindle and by the different outline of the basal cavity.

Icriodus aff. I. arkonensis
(Plate 6, Figures 26-30)

Remarks:
The specimens identified herein as I. aff. arkonensis are similar to I. arkonensis STAUFFER, 1938 by the biconvex to slightly triangular outline of the platform, the transversely expanded lateral-row denticles, the smaller medial-row denticles connected by a longitudinal ridge and the outline of the basal with a prominent spur. However, in the specimens at hand the median ridge is less prominent, they have fewer denticles on the spindle and the posterior extension of the middle row is distinctly longer.

Genus Polygnatus HINDE, 1879
Polygnatus xylus ZIEGLER & KLAPPER, 1976
(Plate 8, Figures 10-14)

* 1976 Polygnatus xylus n. sp. — ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON, pp. 119-120, figs. 11-26.

Remarks:
The specimens identified herein as P. ansatus are characterized by the distinct outward bowing of the outer and inner anterior trough margins. The trough margins, especially the outer, are relatively long. In specimens from the Lower Member of the Fromelles Formation identified as P. aff. P. ansatus (Pl. 8, Fig. 9) the outward bowing of the anterior trough is only weakly indicated and the anterior trough margins are shorter than in typical specimens of P. ansatus. See also under P. hemiansatus.

Polygnatus ensensis ZIEGLER & KLAPPER, 1976
(Plate 7, Figures 1-6)

1970 Polygnatus xyla STAUFFER, 1940 — BULTYNCK, p. 131, partim, pl. 15, figs. 2, 8, non fig. 5 = P. pseudofoliatus.
* 1976 Polygnatus xylus ensensis n. subsp. — ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON, pp. 121-127, pl. 3, figs. 4-9.
1977 Polygnatus xylus ensensis ZIEGLER and KLAPPER, 1976 — WEDDGE, pp. 321-322, partim, pl. 4, figs. 62, 64, 65?, non fig. 63 = juvenile specimen of P. pseudofoliatus or P. eiflius.

Remarks:
Characteristic features of specimens identified herein as P. ensensis include the distinctly serrated anterior platform margins, the straight to steeply downward declined anterior trough margins, meeting the blade at the same position and the posteriorly down-arched platform. In specimens transitional between P. ensensis and P. timorensis (Pl. 7, Figs. 7, 8) only one of the anterior platform margins is serrated and the anterior trough margins decline less steeply downward.

Polygnatus hemiansatus n. sp.
(Plate 7, Figures 16-27; Plate 8, Figures 1-7)

1980 Polygnathus aff. P. ansatus ZIEGLER, W. and KLAPPER, G., 1976 — BULTYNCK & HOLLARD, p. 42, pl. 5, fig. 18; pl. 6, figs. 2-4.
1985 Polygnathus ansatus ZIEGLER and KLAPPER, 1976, early morphotype — BULTYNCK, p. 269, pl. 6, figs. 19, 20.
1987 Polygnathus ansatus ZIEGLER and KLAPPER, 1976 — GARCIA-LOPEZ, pp. 86-87, partim, pl. 11, fig. 23; pl. 12, figs. 1-6, 9; non pl. 12, figs. 7, 8, 10-13.

Derivatio nominis:
Hemi, from ἡμί, Greek, half + ansatus, referring to the similarity to P. ansatus.

Types:
Holotype. I.R.Sc.N.B. N° b1953 (= Pl. 7, Fig. 26).
Paratypes. I.R.Sc.N.B. N° b951 (= Pl. 5, Fig. 18 in BULTYNCK & HOLLARD, 1980), N° b954 - N° b955
Locus typicus: Erfoud (Morocco), Bou Tchrafine section described herein.

Stratum typicum: Bou Tchrafine Group, "Talus Médian", sample 15ter.

Diagnosis:
Platform with a strong constriction at the outer genication point, located at the anterior third of the platform, and with a pronounced convex expansion of the platform margin posterior of this point. Outer anterior trough margin strongly bowed outward. Inner platform margin nearly straight without an outward bowing of the anterior trough margin and serrated just anterior of the genication point. Inner anterior trough margin declining steeply downward. Two genication points generally not opposite and junction of two anterior trough margins with blade at slightly different position. Platform ornamentation nodose to ridged. Blade about half the length of the unit or a little longer and with numerous denticles of about equal height.

Remarks:
Platform characteristics of the new species are best demonstrated in the paratype N° b1955 (Pl. 8, Fig. 1). However, the blade of this specimen is incomplete and therefore the specimen is not designated as Holotype. Lower views of P. hemiansatus are figured in BULTYNCK & HOLLARD (1980, PI. 5, Fig. 18b and PI. 6, Fig. 3b).

P. hemiansatus can be distinguished from P. ansatus by the straight inner platform margin and by the missing outward bowing of the inner anterior trough margin. I recognize a more slender (Pl. 7, Fig. 25) and a broader morphotype (Pl. 7, Fig. 16). The less ornamentated platform, the more sagitate platform outline and the deeper adcarinal troughs distinguish P. timorensis from the slender morphotype of P. hemiansatus.

Polygnathus rhenanus
KLAPPER, PHILIP & JACKSON, 1970
(Plate 7, Figures 13-15)

* 1970 Polygnathus rhenanus sp. nov. — KLAPPER, PHILIP & JACKSON, pp. 655-656, pl. 1, figs. 1-3, 7-10.
1976 Polygnathus rhenanus KLAPPER, PHILIP & JACKSON — ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON, pp. 27-32, pl. 3, fig. 10.
1985 Polygnathus rhenanus KLAPPER, PHILIP & JACKSON, 1970 — BULTYNCK, pl. 6, figs. 17-18.

Remarks:
Representative Moroccan specimens of P. semialternans are illustrated in BULTYNCK & HOLLARD (1980). The occurrence of forms transitional between P. rhenanus (see under P. rhenanus) and P. semialternans suggests that the latter was derived from P. rhenanus. Consequently, the species is assigned here to the genus Polygnathus.

Polygnathus semialternans
(KLAPPER, PHILIP & JACKSON, 1970)

(Plate 7, Figures 9-10)

* 1970 Polygnathus semialternans sp. nov. — KLAPPER, PHILIP & JACKSON, pp. 655-656, pl. 1, figs. 1-3, 7-10.
1976 Polygnathus semialternans KLAPPER, PHILIP & JACKSON — ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON, pp. 27-32, pl. 3, fig. 10.
1985 Polygnathus semialternans KLAPPER, PHILIP & JACKSON, 1970 — BULTYNCK, pl. 6, figs. 17-18.

Remarks:
Differences with P. hemiansatus and with P. rhenanus are discussed under these species.
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IV. Conclusions

The most important conclusions of the present study can be derived from the range chart in figure 9. It shows the correlations of the newly refined local *Polygnathus* zonation (column C) established in the pelagic sequence from the Tafilalt area and of the alternative *Icriodus* zonation (column D), mainly based on the shallow water platform carbonates of the Givet Limestone in the Ardennes, with the standard conodont zonation from the *kockelianus* Zone up to the Upper *varcus* Subzone (column B). All zones and subzones are defined on the basis of first occurrences of one or two species. The reasons for proposing these alternative zonations are discussed in detail in the introduction and under the separate headings of the individual sections. In brief, they comprise different conodont biofacies encountered in the Givet Limestone; the differing taxonomic treatments of *Polygnathus ansatus* and finally the concept and definition of the *varcus* Zone and its subdivisions by Ziegler, Klapper & Johnson (1976).

The earliest occurrences of *Polygnathus eiflius* and *P. hemiansatus* are not only of local interest but here they are proposed to subdivide formally the *kockelianus* Zone and the *ensensis* Zone. The range chart also summarizes the vertical distribution of 29 selected conodont taxa in the two studied areas. The range chart is compared with similar charts established for the same period by Weddige (1977), Clausen, Leuteritz & Ziegler (1979) and Johnson, Klapper & Trojan (1980) for the northern Antelope Range (Nevada). The results of this comparison are presented in table 1.

On the range chart (Fig. 9) the position of the Eifelian-Givetian boundary (column 1) is shown with a question-mark, because definition by the Subcommission on Devonian Stratigraphy is pending. However, at the 1986 and 1987 Subcommission meetings a majority of the members favoured a level at the base of or within the *ensensis* Zone. The provisional positioning of the boundary in the range chart corresponds to the earliest occurrence of *P. hemiansatus* within the *ensensis* Zone. In the Bou Tchrafine section the entry of *P. hemiansatus* coincides with that of *I. obliquimarginatus*. In the Givet Limestone of the type area the entry of the latter species is the most reliable first appearance that is closest to the base of this unit, historically the base for the Givetian stage. *P. hemiansatus* has also been recognized in sections in the Cantabrian Mountains (Spain) and in the Guangxi Province (South China). Consequently its lowest occurrence is considered here as a good potential level for the Eifelian-Givetian boundary.

Table 1

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g: *I. brevis*, *P. ansatus*, *P. beckmannii*, *P. ensensis*, *P. pseudofoliatus*, *P. timorensis*, *T. kockelianus kockelianus*; h: *I. difficilis*, *P. trigonicus*, *P. xylus* xylus; i: *I. obliquimarginatus*, *P. angustipennatus*, *P. eiflius*, *P. intermedius*. 
References


Acknowledgements

The author is indebted to Drs. M. BENSAID and M. DAH- MANI (Direction de la Géologie, Rabat) for issuing a work permit and for logistic assistance during the field work. In 1979 the investigation of the sections in Morocco was carried out jointly with the late H. HOLLAND and with P. SART- NAEK. Field work in Morocco since 1975 has been supported by the Nationaal Fonds voor Wetenschappelijk Onderzoek and by the Internationale Wetenschappelijke Koöperatie, Ministerie van Nationale Opvoeding.

Dr. VAN DEN BOOGAARD (Rijksmuseum van Geologie en Mineralogie, Leiden, The Netherlands) kindly allowed me to study the types and additional material of Icriodus eslaen- sis; he also provided me photographs of I. esluensis speci- mens from the stratum typicum (Fig. 8, a-f). Dr. WANG CHENG-YUAN (Nanjing Institute of Geology and Palaeonto- logy, Academia Sinica) allowed me to figure a specimen of Polygnathus hemiansatus (Pl. 8, Fig. 5) recognized in his collection from the Sihongshan section, Guangxi Province (China). Specimens of P. hemiansatus and P. ansatus (Pl. 8, Figs. 6, 7 and 10, 11) from the Tully Limestone (New York, U.S.) are from samples collected during a joint field trip with Drs. P.H. HECKEL and G. KLAPPER (University of Iowa) in 1972.

V. Appendix:

locality and sample index Mont d’Hars section

France, IGN Mapsheet Givet (XXX-7), Mont d’Hars fortification on the SE side of the Meuse at Givet. All the measured sections are on the south side of the fortification (Fig. 1). Meterage between samples indicated between brackets.

Section A: samples 1 (0.40 m above base of outcrop), 2 (0.90 m), 3 (1.60 m), 3bis (0.40 m), 4 (0.70 m), 5 (0.25 m), 6 (0.90 m), 6bis (0.50 m), 7 (0.45 m), 8 (0.25 m), 9 (0.45 m), 10 (0.65 m, top of outcrop).

Section B: samples 11 (base of outcrop), 12 (0.60 m), 12bis (0.25 m), 13 (0.80 m), 13bis (0.15 m), 14 (0.15 m), 15 (0.75 m), 16 (1.60 m), 17 (1.00 m).

Section C: sample 18 (17.80 m above base of outcrop); samples 19-23, barren.

Section D: samples 24 (base of outcrop), 25 (4.20 m), 26 (4.80 m), 26bis (0.60 m), 27 (0.60 m), 28 (3.45 m), 29 (2.95 m), 30 (2.55 m), 31 (0.40 m), 32 (0.40 m), 33 (5.80 m), 34 (0.15 m), 35 (1.30 m), 36 (13.50 m, poorly exposed), 36bis (0.30 m), 37 (0.45 m), 38 (0.65 m), 39 (1.90 m), 40 (0.45 m), 40bis (1.80 m), 41 (2.30 m, interruption in exposure just below sample), 41bis (1.75 m), 42 (2.10 m), 43 (2.25 m), 44 (1.80 m) 45 (2.35 m), 45bis (3.00 m), 46 (3.65 m), 47 (4.30 m), 47bis (0.80 m), 48 (0.70 m, interruption in section just above sample), 48bis (3.40 m), 49 (0.80 m), 50 (15.00 m), 51 (1.85 m), 52 (2.45 m), 53 (1.65 m).

Section E: samples 54 (9.00 m), 55 (11.00 m), 56 (11.50 m).

Section F: samples 57 (4.00 m, base of outcrop), 58 (0.25 m), 59 (1.10 m), 60 (0.30 m), 61 (0.30 m), 62 (0.40 m), 63 (32.00 m), 64 (4.50 m), 65 (5.00 m, 1 m below top of exposure).

The Geological Association


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Plate 1

Section Akka Bou Khedach, upper part with position of samples 1-3, 7 and 8.
Plate 2

Upper: section Taboumakhlof Terasse, general view.
Lower: detail of the section with position of samples 1, 2 and 4.
Plate 3

NW part of section Taboumakhlouf South with position of samples 1 to 7; sample 1 is at the base and sample 3 at the top of the small cliff; sample 6 is 2.40 m below and sample 7 5.55 m above prominent bed.
Magnification 45×, except where otherwise stated. MH: sample number Mont d’Hauers section; From: sample number Fromelles section; BT: sample number Bou Tchrafine section; ABK: sample number Akka Bou Khedach section; H: sample number Haine Quarry (Bultynck & Godfroid, 1974).


PLATE 5

Magnification 65×, except where otherwise stated.


Plate 6

Magnification 65x, except where otherwise stated.


PLATE 7

Magnification 45×, except where otherwise stated.


Magnification 45×, except where otherwise stated.


Magnification 45×, except where otherwise stated.


Fig. 12. – Polygnathus xylus xylus STAUFFER, 1940. Upper view of I.R.Sc.N.B. N° b1993, MH-33.

Fig. 13. – Polygnathus linguiformis alveolus WEDDGE, 1977. Upper view of I.R.Sc.N.B. N° b1994, MH-3bis.


Fig. 15. – Polygnathus angustipennatus BISCHOFF & ZIEGLER, 1957. Oblique-upper view of I.R.Sc.N.B. N° b1996, MH-3bis.


Fig. 18. – Polygnathus beckmanni BISCHOFF & ZIEGLER, 1957. Upper view of I.R.Sc.N.B. N° b1999, BT-29.

Fig. 19. – Polygnathus linguiformis transversus WITTEKINDT, 1965. Upper view of I.R.Sc.N.B. N° b2000, BT-23.


Fig. 21. – Polygnathus linguiformis aff. klapperi. Upper view of I.R.Sc.N.B. N° b2002, (30×), BT-23.

Fig. 22a-b. – Polygnathus linguiformis mucronatus WITTEKINDT, 1965. Oblique-upper and upper views of I.R.Sc.N.B. N° b2003, N° b2004, BT-29er.

Fig. 23. – Polygnathus linguiformis klapperi CLAUSEN, LEUTERITZ & ZIEGLER, 1979. Upper view of I.R.Sc.N.B. N° b2005, BT-15bis.

