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SHALLOW MARINE BIVALVES AT THE DEVONIAN/CARBONIFEROUS BOUNDARY FROM THE VELBERT ANTICLINE (RHEINISCHES SCHIEFERGEBIRGE)

by

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(4 figures, 1 table and 2 plates)

KURZFASSUNG: Die Schichtenfolge des höchsten Famenniums (Strunium, "Etroeungt") im Raum Velbert (Velberter Sattel, Bergisches Land) besteht aus einem Schichtenkomplex von glimmerreichen Sand- und Siltsteinen, die eine artenreiche Bivalvenfauna enthalten. Es dominieren Vertreter der Pteriomorphia *(Parallelodon, Leptodesma, Actinodesma, Pterinopecten, Newellipecten, Vertumnia, Aviculopecten, Fasciculiconcha, Acanthopecten, Streblopteria, Euchondria, Pernopecten)*. Seltener sind endobenthonische Taxa der Palaeotaxodonta *(Palaeoneilo, "Ctenodonta")*, Heteroconchia *(Paracyclas)* und Anomalodesmata *(Edmondia)*. Vergleiche mit gleichaltrigen, älteren und jüngeren Faunen Mittel- und Westeuropas bestätigen den Übergangscharakter der Bivalvenfauna an der Devon/Karbon-Grenze ohne deutlichen Faunenschnitt.

ABSTRACT: The bivalve fauna of the uppermost part of the Devonian (Strunian, "Etroeungt") succession in a section near Velbert (Velbert Anticline) is contained in a sandstone/siltstone complex and is dominated by members of several groups of pteriomorphs *(Parallelodon, Leptodesma, Actinodesma, Pterinopecten, Newellipecten, Vertumnia, Aviculopecten, Fasciculiconcha, Acanthopecten, Streblopteria, Euchondria, Pernopecten)*. Infaunal bivalves such as palaeotaxodonts *(Palaeoneilo, "Ctenodonta")*, heteroconchs *(Paracyclas)* and anomalodesmatans *(Edmondia)* are minor components of the faunas. Comparison with older, younger and contemporary faunas from Central and Western Europe stress the transitional character of the Velbert fauna : there seems to be a gradual change from the Devonian to the Carboniferous rather than a sharp faunal break across the Devonian-Carboniferous boundary.

INTRODUCTION

The geology and palaeontology of the Velbert Anticline (Rheinisches Schiefergebirge) has been studied for more than 100 years. These studies have focussed mainly on the small "horse shoe" shaped line of outcrops of Lower Carboniferous and Upper Devonian rocks which surround the core of the Velbert Anticline (Fig. 1). A facies change from the shelf region in the North-West to the "basinal" facies in the South-East persists throughout the Famennian and most of the Dinantian. Modern studies are limited to a small number of exposures and disused quarries since the area is densely built-up. Furthermore, facies restrictions of guide fossils cause problems in the correlation of strata, especially near the Devonian-Carboniferous boundary.

The history of research of the Velbert area is discussed at length by Paeckelmann (1913), Paul (1939b), Böger (1962) and Michels (1986). It is noteworthy that despite 100 year's investigation the state of knowledge of the stratigraphy and palaeontology of the area is still fragmentary.

LITHOLOGY AND BIOSTRATIGRAPHY

(Figure 2)

The strata across the Devonian-Carboniferous boundary were exposed during the construction of

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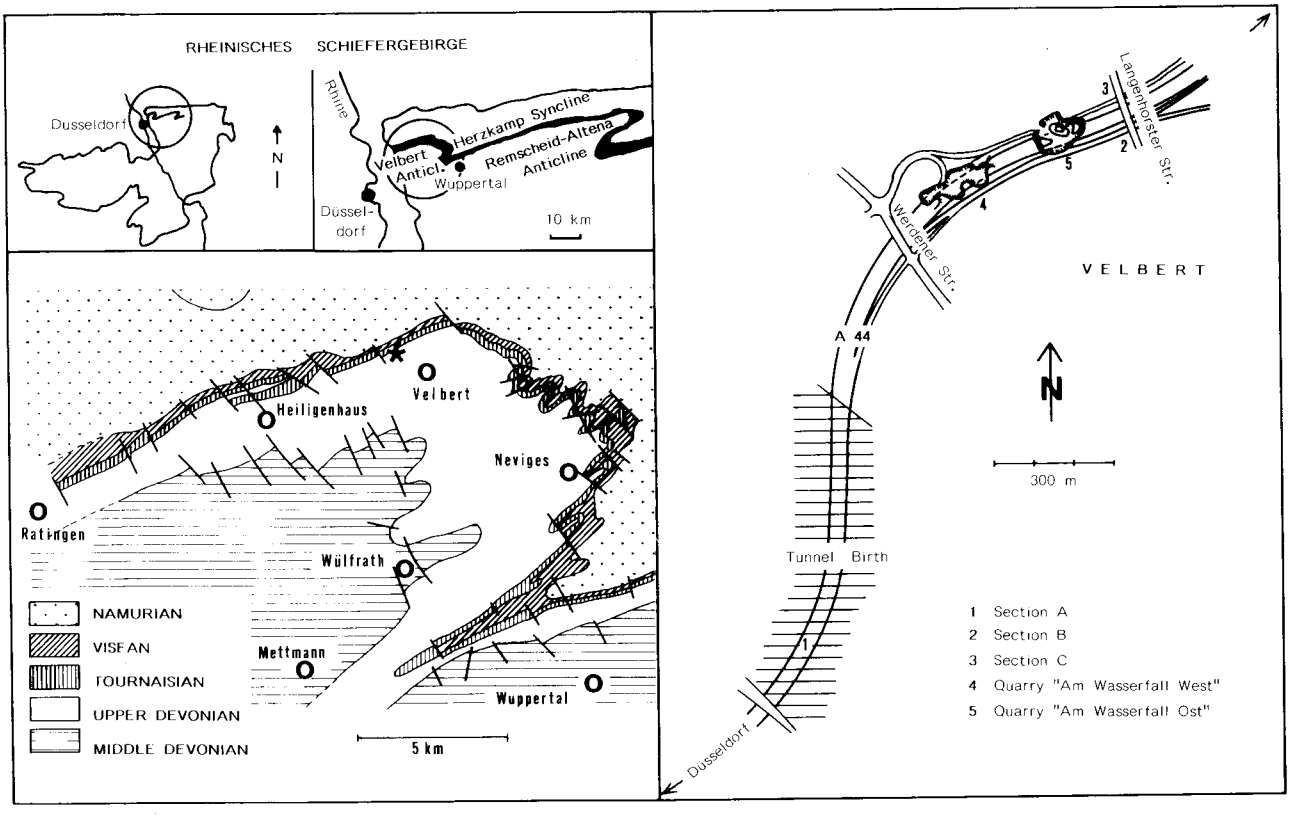


Fig. 1.- Geological sketch-map of the Velbert Anticline (Rheinisches Schiefergebirge) and location map of the roadcut "Autobahnknoten Langenhorst" at the northern periphery of Velbert; modified from Amler *et al.* 1990.

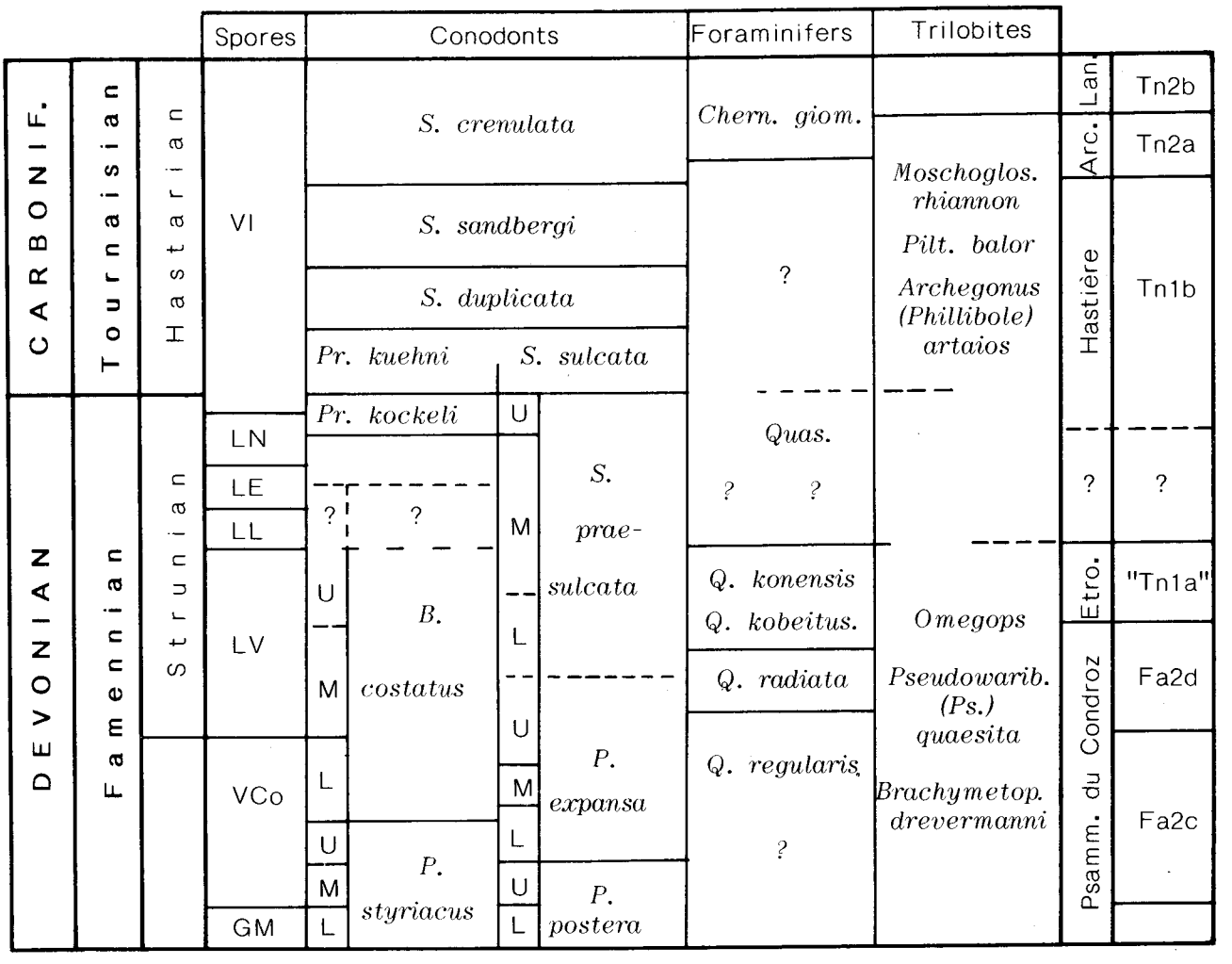
the motorway A 44 Düsseldorf - Bochum at the northern periphery of Velbert between 1975 and 1983. In consequence the two former quarries "Am Wasserfall" have been destroyed and covered. Most of the fossils used by the authors of the "Fauna des deutschen Unterkarbon" (1930-1932) came from these exposures. The present locality is called "Autobahnknoten (motorway junction) Langenhorst" and has been mapped and surveyed during the roadworks by Michels and Thomas (Michels 1986, Thomas 1981, Haude & Thomas 1989).

A precise biostratigraphical interpretation of the sequence and of the former quarries "Am Wasserfall" is not available due to the heterogeneous fossil content of single beds which are difficult to correlate with other areas. Only parts of the succession can be dated using different fossil groups. The stratigraphical basis for the region was established by Paul (1939b) for the Upper Devonian part and by Böger (1962) and Conil & Paproth (1968) for the Lower Carboniferous part. Some refinement and corrections have been added later (e.p. Paproth *et al.* 1973, Franke *et al.* 1975).

The sand-/siltstone unit (beds 20 - 75b)

The oldest rocks occur in the western part of the section; now covered by the motorway noise prevention tunnel "Birth" (Fig. 1). The section there starts with a succession of micaceous, clayey-carbonaceous siltstones. Some of these beds have yielded a few bivalves. The central part of the unit (beds 40-70 of Michels) consists mainly of greenish to ochreous siltstones interfingering with siltstones 2 to 8 cm thick sandstone and weathered calcareous sandstone beds. Fossils are restricted to single layers, some of which are very fossiliferous; certain beds yield monospecific layers of plant remains, brachiopods, or ophiuroids. The fauna includes crinoids, brachiopods, bryozoans, corals, trilobites, and bivalves. The upper part of the unit, the strata between beds 70 and 75b, is characterized by very fossiliferous clayey or carbonaceous siltstones. Fossils include brachiopods, bryozoans, corals, trilobites, crinoids, and most of the bivalves studied. For this sand-/siltstone unit, i.e. the lower part of the whole succession, Paul (1939b) introduced the term "Angertal-Schichten" of Etroeungtian (s. str.) age. Paul's subdivision of the

Table 1.- Tentative correlation chart of miospore, conodont, foraminifer and trilobite zonation at the Devonian-Carboniferous Boundary in the Franco-Belgian Basin; modified from Conil *et al. 1986, Fig. 1 and completed after Hahn* et al. 1988 and Brauckmann & Hahn 1984.



As yet, conodonts have been recorded only from the lower part of the unit. Michels (1986) recorded *Bispathodus ultimus, Bispathodus ziegleri, Bispathodus costatus* and *Bispathodus bispathodus* within the lower oolitic and micritic limestones (Beds 75-78 (Fig. 2). Accordingly this part correlates with the Middle to Upper *costatus* Zone (resp. Lower to Middle *praesulcata* Zone). Spores and foraminifers from this section have not been studied satisfactorily but a resurvey of the region is in progress by a Marburg Working Group.

The main upper part of the oolitic sequence is very poor in conodonts and lacks indicative fossils (Franke *et al.* 1975). Its presumed age (Tn 1b; Lower Hastarian) is only indirectly confirmed by the fauna of the succeeding beds. Therefore, the Devonian-Carboniferous boundary is presently drawn within the middle or upper part of the oolites, as already suggested by Böger (1962).

The Tournais-Zwischenschiefer (beds 81 - 85)

The oolitic limestones are overlain by carbonaceous, shaly siltstones reaching a maximum thickness of some 3 m, partly rich in plant remains (Fig. 2). A few layers yield brachiopods, bryozoans, trilobites, echinoderms, gastropods etc. (Michels 1986). On the basis of conodonts faunas, the siltstones belong to the *Siphonodella crenulata* Zone (Tn 2; Upper Hastarian; cd II alpha; Franke *et al.* 1975, Böger 1962).

Richrath Limestone and "Carboniferous Limestone" (beds 86 et seq.)

The upper part of the sequence consists of bioclastic limestones (crinoidal limestone) and turbiditic limestones. They reach some 80 m in thickness. The crinoidal limestone at the base of the carbonate unit was called "Erdbach Limestone" by Paul (1937b) and Richrath Limestone by Böger (1962). The upper series of limestones is known as "Carboniferous Limestone" (Kohlenkalk) of the Velbert Anticline. Paul (1937b:49; 1954) gave a full account of the fossil content of the Richrath Limestone and placed it at the base of the Viséan (cf. Böger 1962). It contains a high percentage of reworked organisms and particles, among others conodonts of the Lower to Upper *Polygnathus carina* Zone and the *Scaliognathus anchoralis* Zone. Accordingly a position at the Tournaisian/Viséan Boundary (Upper Ivorian/ Lower Moliniacian) is confirmed. The base of the bioclastic limestones corresponds to an hiatus extending probably from Tn 3a to Tn 3c (Paproth *et al.* 1973).

The main upper part of the calcareous unit, called "Carboniferous Limestone" in the literature, is of Viséan age but is not precisely dated. It seems likely that the calcareous facies persisted at least from the Early Moliniacian to Early Warnantian time. The main part of the limestone unit in the nearby exposures of Hefel and Sondern is of Moliniacian age and extends up to the Livian or earliest Warnantian (Paproth *et al.* 1973).

The topmost part of the section is formed by an alternation of thin limestones and argillaceous shales and cherts of the Culm facies.

ON THE BIVALVE FAUNA NEAR THE DEVONIAN-CARBONIFEROUS BOUNDARY IN THE VELBERT AREA

The majority of fossils from the Upper Famennian sand-/siltsone units has been studied by the working group on the "Fauna des deutschen Unterkarbon" (1930-1932) on the assumption that they were of lowermost Carboniferous age. Paul (1939b) presented a revised fossil list. Michels (1986) analyzed the palaeoecology of Bed 71 without taxonomic revision of the fauna. As mentioned above, most of the beds are poor in fossils, whereas some individual beds yield a rich fauna. Brachiopods are the most important element; they show a high diversity and amount to more than 50 % of all individuals. The second important group are ostracodes with up to 30 % of the total fauna and a relatively low diversity. Bryozoans are common and all other groups occur as minor faunal elements (1-2 %) numerically important only in particular layers (especially bivalves, ophiuroids, crinoids).

The last account of the bivalves of the region was given by Paul (1941, 1954) based on his own material and the collections of Kayser (1882), Drevermann (1902) and Paeckelmann (1913). He listed 45 bivalve taxa and one rostroconch *(Conocardium),* nine of these were nomina nuda. Most of the material has been studied by the present author in the collection of the former ZGI (Bernau/Berlin) to add information to the collection from the section studied. After a first brief summary on the bivalve fauna (Amler 1989, Amler *et al.* 1990) taxonomic revision is in progress to provide a definitive version of the provisional list, shown below, in the future:

Palaeotaxodonta:
**Palaeoneilo lirata* (Phillips 1841)
Palaeoneilo antiqua (Sowerby 1840)
**Palaeoneilo* cf. *emarginata* (Conrad 1841)
Palaeoneilo? sp. nov. 1

Isofilibranchia:
Modiolus sp.

Pteriomorphia:
Parallelodon cf. *meridionalis* deKoninck 1885
Parallelodon sp. 1
Parallelodon sp. 2
**Leptodesma (L.) anatinum* Whidborne 1897
**Leptodesma (L.) cultellatum* Whidborne 1897
**Leptodesma (L.)* cf. *eberti* (Frech 1891)
**Actinodesma (A.) angulosa* (Whidborne 1897)
**Pterinopecten polytrichus* (Phillips 1841)
**Pterinopecten mundus* Whidborne 1897
Pterinopecten? sp., aff. *P. eximius* (deKoninck 1885)
**Newellipecten? austeni* (Roemer 1855)
Vertumnia sp.
**Aviculopecten? halli* (Whidborne 1897)
**Aviculopecten* cf. *nexilis* (Sowerby 1840)
Aviculopecten cf. *aquisgranensis* Frech 1891
Aviculopecten? sp., aff. *A. serratus* (McCoy 1844)
Aviculopecten? sp., aff. *A. clathratus* (McCoy 1844)
Undopecten sp. nov. 1
**Fasciculiconcha transversa* (Sowerby 1840)
**Acanthopecten?* sp.
Streblochondria sp.
**Streblopteria piltonensis* (Whidborne 1897)
**Euchondria vera* Drevermann 1902
Euchondria beushauseni Drevermann 1902
**Pernopecten* sp. nov.
Palaeolima ? sp.

Heteroconchia:
Paracyclas sp.

Anomalodesmata:
Edmondia sp.

Species indicated with an asterisk (*) are briefly described in the palaeontological part.

From other localities of similar age Kayser (1882), Drevermann (1902) and Paul (1939b, 1941, 1954) collected:

Prothyris bergica Drevermann 1902
Sanguinolites lintorfianus Paul 1938
Sanguinolites sp.
Parallelodon sp. 3
Parallelodon sp. 4
"Ctenodonta"? ratingensis (Paeckelmann 1913)
Ptychopteria damnoniensis (Sowerby 1840)
Aviculopecten sp. nov.
"Posidonia" sp.
Cypricardinia sp.

These specimens need further study as they have been discovered very recently in the collection of the former ZGI (Bernau/Berlin).

As the list shows, the fauna consists mostly of pteriomorphs, especially species of the Pteriacea, Pterinopectinidae and Aviculopectinidae. Species of all three groups also reach considerable individual size, up to 100 mm, exceeding the size of specimens from other localities where they occur.

The several species of *Leptodesma* are difficult to determine because there are hundreds of "taxa" (i.e. names) known from the Devonian and Carboniferous of Europe and North America, but only a very small percentage of real species will remain because all ecological variants have been given specific names in the past. Revision is necessary to reduce the number of species and genera.

In contrast, pterinopectinids and aviculopectinids show a greater variety of species. Most of them probably gave rise to the highly diversified group in the Late Tournaisian and Viséan. As yet phylogenetic relations between the different genera and species are uncertain because there is uncertainty about apomorphy and plesiomorphy of morphological characters. General tendencies are shown in Figure 3. The presence of *Actinodesma (A.) angulosa* and *Vertumnia* sp., is important for biostratigraphical use

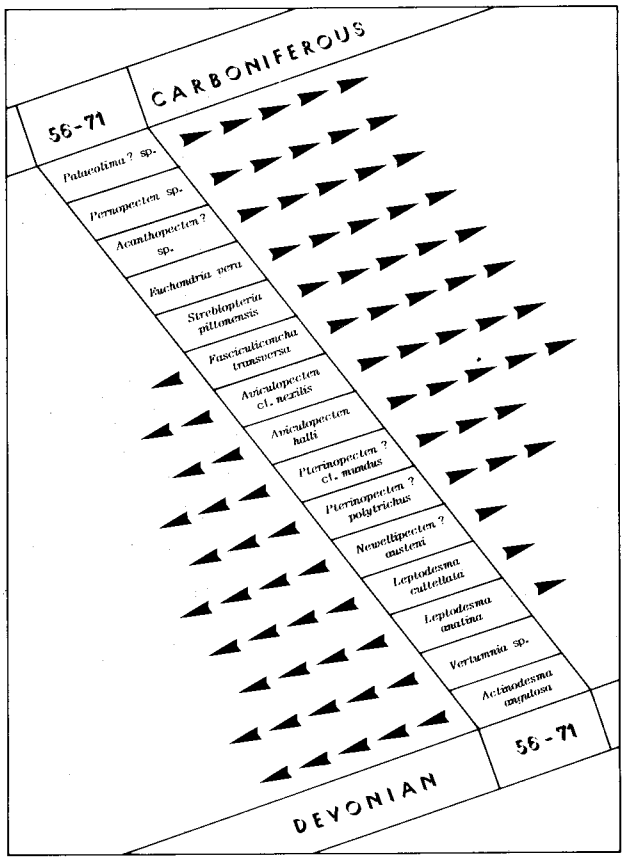


Fig. 3.- General phylogenetic relations of selected bivalve taxa in the latest famennian. Arrows indicate relative relations to Devonian ancestors and Carboniferous descendents.

because both have never been recorded from strata of Lower Carboniferous age.

Few species of *Parallelodon* occur in the fauna studied. They form the origin of a great radiation of parallelodontids in the early Tournaisian with species occupying a wide range of different habitats.

Palaeotaxodonts are difficult to deal with because there are lots of "ctenodont" species which have been described from the Devonian and Carboniferous that commonly show very few differences in morphology; many have been founded on insufficient type material and/or without precise diagnoses. Only a few taxa have been examined by statistical methods (cf. Hajkr *et al.* 1968), but Murphy (1966) stated that within these groups even statistical methods probably are insufficient for definition of species (cf. Amler 1987).

In faunal bivalves of the subclasses Heteroconchia, Isofilibranchia, and Anomalodesmata occur only sporadically. Their rare occurrence depended on the ecological conditions within the open marine clastic shelf environment.

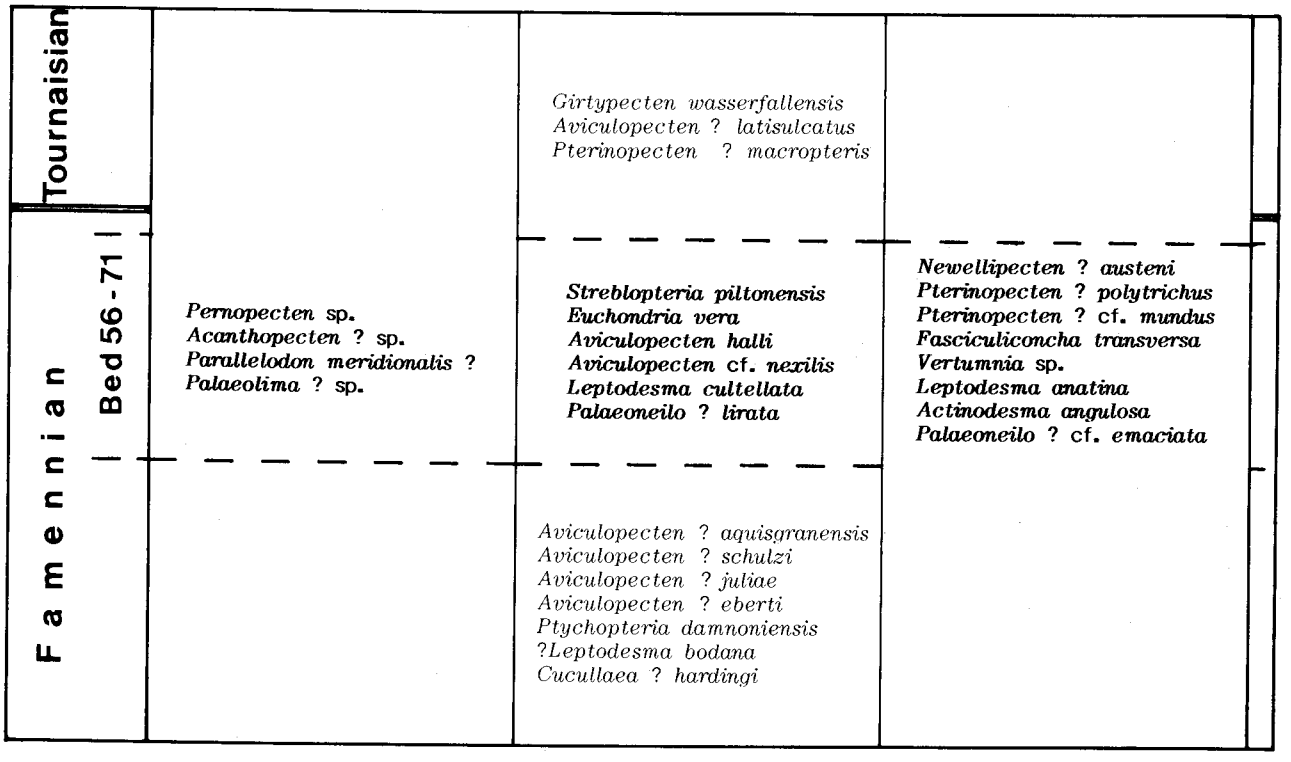


Fig. 4.- Stratigraphical distribution of bivalves at the Devonian-Carboniferous Boundary in the Velbert Anticline

CORRELATION AND CONCLUSION

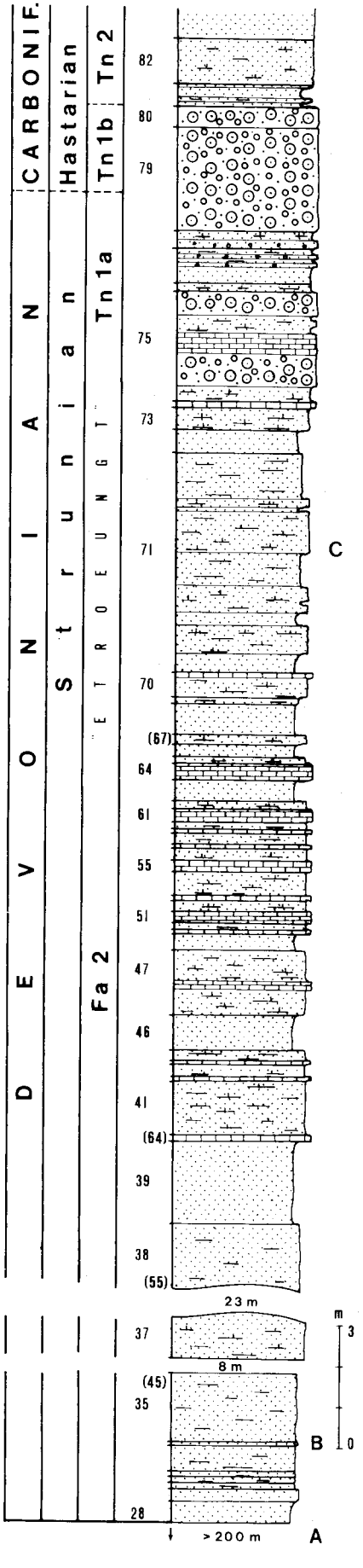
The bivalve fauna from Velbert has been compared with older and younger faunas as well as faunas of similar age from different areas in Europe. Always bearing in mind the poor state of knowledge in bivalve taxonomy, some preliminary results have been observed:

1. The shelf fauna from Velbert shows close similarities to the fauna of the Pilton Beds in SW-England. This fauna was described by Whidborne (1896-1907) and is under study by the present author. Comparison and correlation of both faunas is limited, because ecological conditions in both areas were not influenced by drastic change at the Devonian-Carboniferous boundary and similar facies conditions persisted in both areas at least from Late Famennian to early Dinantian time. In SW-England the Pilton Facies seems to have persisted into the Late Tournaisian (Goldring 1970, Edmonds *et al.* 1985), but no bed-by-bed collections are available from dated sections across the Devonian-Carboniferous boundary. Where old fossil localities have been dated subsequently as Pilton A (= uppermost Famennian) both regions show almost identical taxa at the species level.

2. The Etroeungt Limestone and the basal part of the Calcaire d'Hastière, both about the same age as the section under study, have yielded very few bivalves up to now. Dehee (1929) mentioned only one taxon, *Pterinopecten radiatus* Phillips 1836, from the type locality of the "Etroeungt" in N-France. Demanet (1958) listed 13 taxa altogether from the Tn 1a of Belgium, 6 species of *Aviculopecten,* 3 *Pernopecten,* one *Pterinopecten,* 2 *Grammatodon (= Parallelodon)* and one *Edmondia,* but no taxonomic study of this fauna has been made. Judging from this list general similarities at the generic level and the composition of the fauna are obvious.

3. The Devonian-Carboniferous transition in Poland has been investigated for many years from exposures and several boreholes (a.o. Korejwo 1975, 1976, 1979 etc.). Unfortunately, most of the material is in a quite fragmentary state of preservation, preventing exact taxonomic studies. But nevertheless, relatively close connections between both areas, Poland and Velbert, can be seen, especially in the composition and diversity of the faunas. This applies, of course, more to localities which were in a similar palaeogeographical nearshore position than to Culm facies localities, the latter increasing in similarity during the Viséan.

4. The bivalve faunas of the Upper Cypridina Shales and the Wocklum Shales of the Rheinische Schiefergebirge are similar in age to the fauna studied here. However, they bear very little similarity in composition and diversity as they represent totally different environments. Both bivalve faunas have in



Etroeungtian into three, E alpha, E beta, and E gamma by the use of brachiopods, and later refined by Goldring (1957) is only partly comprehensible in the section studied (Michels 1986). The guide brachiopods display different ranges in Western and Eastern Europe which causes difficulties in the correlation with other fossil groups (Matija 1986, Avchimovitch *et al.* 1988, Legrand-Blain & Martinez 1988). *Sphenospira julii* (below Bed 30), *Aulacella interlineata* (Beds 65-75b) and *Aulacella bergica* (Beds 67-71n) as well as *Eobrachythyris strunianus* (Bed 71) and *Whidbornella caperata* (Beds 71-75b) are limited to the Upper Devonian. With one exception goniatites are absent in the section studied; one specimen of *Cyrtoclymenia* sp. is recorded from Bed 71 (Michels 1986). According to Price & House (1984) cyrtoclymeniids persist until late "Strunian" time. Stratigraphically most important are trilobites. The occurrence of *Phacops (Omegops)* sp. ("*Phacops accipitrinus accipitrinus* Phillips 1841" of authors), *Pseudowaribole (Ps.) quaesita* Hahn & Brauckmann 1984 and *Brachymetopus (B.) drevermanni* G. Hahn 1964 up to Bed 71 indicates an uppermost Devonian age, as all three taxa are not known in Lower Carboniferous strata (Brauckmann *et al.*, this volume).

The oolite-siltstone unit (beds 75c - 80)

With Bed 75 a sequence of oolitic limestones, silty shales and carbonaceous siltstones begins, totalling 4-6 m in thickness. The beds yield a sparse fauna and flora of brachiopods, echinoderms, trilobites, gastropods, corals, conodonts, and algae (Franke *et al.* 1975, Michels 1986), none of which have stratigraphical significance. Paul (1937b, 1938b) placed the oolites in the topmost "Etroeungtian"; Paeckelmann (*in* Bärtling & Paeckelmann 1928) used the first oolitic bed as the base of the Tournaisian.

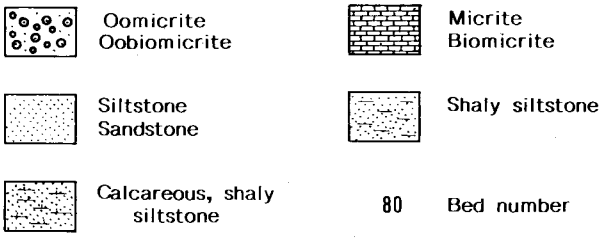


Fig. 2.- Columnar section of the roadcut "Autobahnknoten Langenhorst" near Velbert (Velbert Anticline); modified from Michels (1986, Appendix, section 1) and completed after Thomas (in Brauckmann & Meyer 1982) and Amler *et al.* 1990. Bed numbers in brackets refer to the differing bed numbers of Thomas.

common members of the Palaeotaxodonta (though differences at the species level are distinct), and *Posidonia (Guerichia* or *Karadjalia* of authors). Characteristic taxa of the Dasbergian and Wocklumian in shaly facies such as *Ontaria, Chaenocardiola,* or *Loxopteria* (cf. Schmidt 1924) are absent in the Velbert faunas, whereas the large, coarse sculptured members of the Pteriomorphia are missing in the shales of the central Schiefergebirge. Detailed investigations of bivalves of this biofacies is in progress (Amler in prep.).

5. The bulk of the early Famennian and Frasnian bivalve faunas differs distinctly from the fauna studied here. Diagnostic Devonian genera such as *Buchiola, Actinodesma,* or *Paracyclas* are represented by very few taxa which are not known in Lower Carboniferous strata. Other common Devonian taxa such as *Praecardium, Cardiola, Opisthocoelus, Gosseletia, Prosochasma, Loxopteria (Kochia), Carydium,* or *Prosocoelus* were already extinct or were restricted to different palaeogeographical areas.

6. Several taxa of pteriomorphs and palaeotaxodonts display no diagnostic relations to earlier or later faunas (see Fig. 3). They evolved from a diverse group of Devonian ancestors and persisted across the Devonian-Carboniferous boundary with Dinantian descendants, although detailed lineages are unclear. A detailed systematic study of species may clarify the phylogeny soon. However, species of *"Ctenodonta"* and *Palaeoneilo* show a wide range of diversity in the Devonian and Carboniferous and no precise information is known about diagnostic features at the specific level. Similar problems arise in the study of trigoniaceans *(Schizodus)* and pteriaceans *(Leptodesma, Leiopteria),* both of which display non-distinctive or habitat controlled morphology.

7. Several taxa of the Pterinopectinidae, Aviculopectinidae, Parallelodontidae, and Edmondiidae derive from a small stock of (Upper) Devonian ancestors, increase in diversity during the uppermost Famennian and reach an acme in the Late Tournaisian and Viséan. This radiation took place in favourable ecological conditions in diversified shelf areas during latest Famennian time and continued during the Lower Carboniferous and gave rise to several pectinacean taxa. Accordingly, these groups show closer relations to the bivalve fauna of the Anglo-Brabant Tournaisian and little connections to the Rhenish Devonian. Further studies on bivalve systematics and taxonomy are necessary to comment on biostratigraphical guide taxa (Fig. 4).

8. In general, the bivalve fauna of the clastic marine shelf regions shows a transitional character from the Devonian to the Carboniferous. Although a few taxa became extinct at or near the end of the Famennian, there is a successive evolutionary transition across the Devonian-Carboniferous boundary rather than a sharp faunal change or break. This remains quite concealed as it is linked with the development of the different facies zones which display an environmental change during early Tournaisian time in most parts of Central Europe. An exception is the southwestern part of England, as mentioned above, but dated bivalve collections from the Upper Pilton Formation (Lower Carboniferous) are very rare. Accordingly, a biostratigraphic boundary is dracon in several sections where facies conditions changed.

PALAEONTOLOGICAL DESCRIPTIONS

Subclass Palaeotaxodonta Korobkov 1954
Superfamily Nuculanacea Adams & Adams 1858

Palaeoneilo Hall & Whitfield 1873

***Palaeonello lirata* (Phillips 1841)**
Pl. 1 Fig. 1

Synonymy: See Amler *et al.* 1990: 47.

Material: 2 internal, 1 external mould.

Description: Outline transversely oval; anterior margin sharply convex; posterior part of shell rostrate prolonged, stressed by a shallow sinus in posterior part of ventral margin; umbos prominent, prosogyrous, situated just anterior to midpoint of dorsal margin. Exterior of shell covered by delicate, regular, commarginal threads; interspaces covered by additional 5-7 microscopic growth lines.

Remarks: There is less variation in the species than assumed by Whidborne who includes several different morphotypes in one taxon some of which are clearly different from the type.

Occurrence: Autobahnknoten Langenhorst; Pilton Formation A; Baggy Formation?

***Palaeoneilo* cf. *emarginata* (Conrad 1841)**
Pl. 1 Fig. 2

Synonymy: See Amler *et al.* 1990: 47.

Material: 5 internal, 4 external moulds.

Description: Several specimens show a distinctive transverse elongation of the posterior part of the shell; posteroventral margin concave, formed by a shallow sulcus on posterior umbonal slope. Surface of shell ornamented with sharp, erect, commarginal threads; the interspaces are covered with numerous, very minute growth lines. Umbos prosogyrous and elongated, situated in the anterior portion of the dorsal margin.

Remarks: The specimens under discussion strongly resemble elongate specimens from the Hamilton and lower Chemung Formation (Middle--Upper Devonian) of North America (Hall 1885, Pojeta *et al.* 1986) which nowadays are united as *P. emarginata* (cf. Bailey 1983). These specimens, too, show close similarities to *P. angusta* Hall 1885 with the exception that *P. angusta* is characterized by having two radial sulci on the posterior part of the shell. *P. emarginata* belongs to the group of most elongated morphotypes of *Palaeoneilo.*

Occurrence: Autobahnknoten Langenhorst.

Subclass Pteriomorphia Beurlen 1944
Superfamily Pteriacea Gray 1847

Actinodesma Sandberger 1854 (1856)
***Actinodesma (Actinodesma)* Sandberger 1854 (1856)**
***Actinodesma (Actinodesma) angulosa* (Whidborne 1897)**
Pl. 1 Fig. 6

Synonymy: See Amler *et al.* 1990: 48.

Material: 1 internal, 1 external mould.

Description: Outline pteriiform; anterior and posterior part of hinge line strongly extended, hinge margin long, straight; central body of shell triangular; posterior wing flattened, posterior margin very gently convex forming a right angle with the posterior extension of the hinge margin; anterior auricle large, inflated, separated from central part of shell by a deep, prominent sulcus, anterior extension of hinge margin flattened. Umbo small, slightly raised above hinge margin. Exterior surface of shell covered with minute, sharp, regularly spaced commarginal lines.

Remarks: Several species of *A. (Actinodesma)* and *A. (Ectenodesma)* are known from Lower Devonian and Middle Devonian strata of Germany and North America (Frech 1891, Hall 1884). There is a gap in the record in the early Upper Devonian. *A. (A.) angulosa* seems to be the last taxon of this group of pteriomorphs which is unknown in the Dinantian. Whidborne erected for this taxon the "provisional" genus *Cobracephalus* Whidborne 1897 which is a subjective junior synonym of *A. (Actinodesma).*

Occurrence: Autobahnknoten Langenhorst; lower Pilton Formation A.

Leptodesma Hall 1883
***Leptodesma (Leptodesma)* Hall 1883**
***Leptodesma (Leptodesma) anatinum* Whidborne 1897**
Pl. 1, Fig. 4, 7

Synonymy: See Amler *et al.* 1990: 48.

Material: 6 internal, 6 external moulds.

Description: Outline characteristically triangular-pteriiform; hinge margin long, straight, drawn out into a long, posterior spine (usually not preserved); central part of shell posteroventrally increasing in breadth; line of maximum convexity (= oblique length) slightly curved; angle between hinge margin and oblique length about 30-40°; posterior wing triangular, flattened, marked off from central body of shell with a gently curved slope, posterior margin strongly concave; anterior auricle nasute, separated from central body of shell by a narrow sulcus, forming a sinus in anterior part of ventral margin. Surface of shell covered by irregularly spaced, prominent, commarginal growth lines.

Remarks: There may be close relations to North American species of *L. (Leptodesma)* as pointed out by Bailey (1983) but as the phylogenetic concept of *Leptodesma* and allied pterineids is poorly understood it remains uncertain to decide, whether "species" are ecological variants or biological species (cf. McAlester 1962, Amler 1987).

Occurrence: Autobahnknoten Langenhorst; Pilton Formation A.

***Leptodesma (Leptodesma) cultellata* Whidborne 1897**
Pl. 1 Fig. 3

Synonymy: See Amler *et al.* 1990: 48 and Amler (in prep.).

Material: 4 external moulds.

Description: Gross morphology like *L. (L.) anatinum* (see above) but angle between hinge margin and line of maximum convexity about 20°. Central body of shell sabre shaped, elongate and gently curved. External surface covered by minute, sharply raised commarginal threads.

Remarks: In contrast to other pterineids of the fauna studied the four specimens display constantly the very small angle between hinge margin and oblique length causing a strongly developed streamlined appearance. No comparable species are known from the German Devonian; a quite similar morphotype, *L. (Leiopteria) emaciata* deKoninck 1885, occurs in the Waulsortian of Belgium.

Occurrence: Autobahnknoten Langenhorst; Pilton Formation A.

***Leptodesma (Leptodesma)* cf. *eberti* (Frech 1891)**
Pl. 1 Fig. 5

Synonymy: See Amler *et al.* 1990: 48.

Material: 3 external, 1 internal mould.

Description: Outline pteriiform, central body of shell triangular in shape, its breadth rapidly increasing posteroventrally. Angle between line of maximum convexity (oblique length) and hinge margin large (50-60°). Posterior wing large, flattened, separated from central body of shell by a very sharp, straight, steep slope. Anterior auricle nasute, separated by a narrow, distinct sulcus. Exterior surface of shell covered by irregularly spaced, commarginal lines of growth.

Remarks: The general features of the specimens studied are similar to *L. (L.) eberti* but the type of this species is not complete. In the Anglo-Brabant limestone facies of Dinantian age *L. (Leiopteria) laevigata* McCoy 1844 and *L. (Leiopteria) maccoyi* deKoninck 1885 resemble the specimens under discussion but show differences in the morphology of the anterior auricle and in a gently curved line of maximum convexity.

Occurrence: Autobahnknoten Langenhorst.

Superfamily Pectinacea Rafinesq ue 1815

Newellipecten Ruzicka, Prantl & Pribyl 1959

Newellipecten? austeni (F. A. Roemer 1855)

Pl. 1 Fig. 8

Synonymy: See Paul 1941: 215 and Amler *et al.* 1990: 49.

Material: 4 internal, 3 external moulds.

Description: Outline pterinopectiniform, prosocline; hinge margin long, straight, usually forming greatest length of the shell; posterior wing large, triangular, flattened, distinctly marked off from central body of shell by a steep slope, posterior margin of wing concave and forming an acute angle with the posterodorsal margin; anterior auricle small, flattened, triangular, separated by a distinct sulcus forming a narrow sinus in anterior margin; umbos prominent, broad, prosogyrous, slightly raised above hinge margin; ventral margin of central body of shell more convex posteriorly than anteriorly producing a pteriiform appearance. Surface of shell covered by conspicuous strong, acute, very distant radiating ribs, very rarely increasing in number by intercalation; radial elements crossed by prominent, regular and distant growth lamellae, sometimes forming spines as they cross the radial ribs; both elements resulting in a very coarse reticulate ornament of the outer shell surface.

Remarks: The material hitherto known from the Pilton Formation is very incomplete and the type material of Roemer is probably lost (pers. comm. Dr. E. Gröning, Clausthal-Zellerfeld). No details of the hinge and ligament are known. Observations on the ontogeny show a distinct change of proportions of the outline of the posterior wing in relation to the central body of the shell. It is uncertain whether the species is a member of *Newellipecten* Ruzicka, Prantl & Pribyl 1959 known from the Lower and Middle Devonian of Central Europe or whether it belongs to the more modern genus *Girtypecten* Newell 1938/39. *Girtypecten tesselatus* (Phillips 1836) from the Visean is very similar with the exception that *G. tesselatus* has only ribs of one order which do not increase in number by intercalation. A definite generic assignment is impossible as long as the characters of the ligament are unknown.

Occurrence: Autobahnknoten Langenhorst; Pilton Formation A, B?

Pterinopecten Hall 1883

Pterinopecten polytrichus (Phillips 1841)

Pl. 1 Fig. 11-12

Synonymy: See Paul 1941: 191 and Amler *et al.* 1990: 49.

Material: 8 internal, 5 external moulds, damaged.

Description: Specimens large, their length exceeding 45 mm; outline pterinopectiniform, hinge margin long, straight, nearly equalling total length; posterior wing large, flattened, triangular, not clearly separated from central body of shell, posterior margin gently concave; anterior auricle small, separated by a narrow sulcus; umbos small, hardly raised above hinge margin, situated in anterior third of hinge margin. Surface of shell with distinct ornament: central body of shell ornamented with about 10 main radiating ribs of first order bearing node like thickenings; interspaces bisected by intercalate radiating ribs of second order and remaining interspaces again bisected by radiating ribs of third (and rarely of fourth) order. Hind wing covered with about 15-20 radiating ribs of irregular distance.

Remarks: All the material of Phillips (1841) and Whidborne (1897) as well as the material studied are very imperfectly preserved; thus complete revision is necessary to define and precise by describe the species. The very distinctive ornament which can be identified even in fragments distinguishes *P. polytrichus* from all other pterinopectinaceans but the material is not adequate to decide whether the species has to be placed in *Pterinopectinella* Newell 1938/39 rather than in *Pterinopecten.*

Occurrence: Autobahnknoten Langenhorst; Pilton Formation A.

Pterinopecten mundus Whidborne 1897

Pl. 1 Fig. 9-10

Synonymy: See Amler *et al.* 1990: 49.

Material: 3 internal, 2 external moulds.

Description: Outline pterinopectiniform, height exceeding length of shell; hinge margin long, straight, shorter than maximum length of the shell; posterior wing large, triangular, marked off from central body of shell by an ill defined slope; anterior auricle of left valve small, triangular, flattened, separated by a steep slope and small byssal sinus. Umbos hardly raised above hinge margin, situated in anterior half or third of hinge margin; anterior, ventral and ventral part of posterior margins more or less equally rounded. Surface covered with about 20 radiating pairs of ribs, the anterior rib of each pair sometimes more prominent than the posterior; consequently, narrow V-shaped and broadly concave interspaces between ribs alternate; hind wing with about 10 prominent, rounded ribs; anterior auricle of left valve ornamented with minute growth lines.

Remarks: Again, no well preserved type material is present which requires detailed study of new material (Amler in prep.).

Occurrence: Autobahnknoten Langenhorst; Pilton Formation A.

Aviculopecten McCoy 1851

Aviculopecten? halli (Whidborne 1897)

Pl. 2 Fig. 7

Synonymy: See Amler *et al.* 1990: 50.

Material: 5 internal, 5 external moulds.

Description: Outline pectiniform, acline or slightly opisthocline; shell higher than long; hinge margin shorter than greatest length; ears small, distinctly marked off, anterior and posterior ears nearly equal in length; anterior ear with shallow byssal sinus; umbo hardly raised above hinge margin. Surface ornamented with rounded, thread-like radiating ribs, increasing in number by intercalation to about 30-35; radial ribs and furrows crossed by sharply raised commarginal growth lines causing a general reticulate appearance; remarkably finer ornament on posterodorsal region; reticulate ornament on anterior auricle weakly developed, more prominent on posterior auricle.

Remarks: Whidborne placed the species with doubts in the genus *Pterinopecten* with reference to the development of the ears. At present no details of the hinge characters have been observed but it seems more likely that the species shoud be referred to *Aviculopecten* or related genera on the basis of its gross morphology.

Occurrence: Autobahnknoten Langenhorst; Pilton Formation A.

***Aviculopecten* cf. *nexilis* (Sowerby 1840)**
Pl. 2 Fig. 4-5, 14

Synonymy: See Paul 1941: 213.

Material: 12 internal, 7 external moulds.

Description: Outline pectiniform, very slightly opisthocline; ears of both valves flattened, distinctly marked off from central body of shell by narrow sulci; anterior ears slightly longer than posterior; right valve with triangular posterior ear and spoon-shaped anterior ear, the latter ventrally bounded by a deep byssal notch; both ears of left valve triangular in shape with nearly parallel anterior and posterior margins; umbos small, pointed, proximate to hinge margin. Surface of shell covered with numerous (about 50), irregularly spaced radiating ribs of varying size but usually thin; new ribs appear intercalated; commarginal lines of growth well developed but weaker than radial ornament; anterior ear of right valve with coarse radial ribs and acute, raised commarginal lines; ornament on posterior ear of right valve and on both ears of left valve more delicately developed than on central body of shell.

Remarks: This species is not well known as the type and the associated material is poorly preserved.

Occurrence: Autobahnknoten Langenhorst; Pilton Formation A; Baggy Formation?

Fasciculiconcha Newell 1938/39

***Fasciculiconcha transversa* (Sowerby 1840)**
Pl. 2 Fig. 1-2, 15

Synonymy: See Paul 1941: 211.

Material: 12 internal, 10 internal moulds, partly damaged.

Description: Shell large, up to 80 mm length and height; right valve obliquely oval in outline, ears distinctly marked off from central body of shell, both ears nearly equal in length, anterior ear with characteristically convex anterior and ventral margins and very deeply indented byssal notch, posterior ear acute, triangular, with slightly concave posterior margin; umbo central, moderately inflated and hardly raised above hinge margin. Left valve with subequal ears, both being triangular, flattened, with nearly parallel anterior and posterior margins; umbo of left valve more acute. Surface of both valves ornamented with 30-40 radiating ribs of first order, increasing in number by intercalation, each first and in rib being accompanied on both sides by a smaller rib; these tripartite fascicles being separated from each other by smooth, concave furrows; radial ribs crossed by fine, irregularly spaced growth lines; ornament on ears of left valve delicately reticulate, the same on the posterior auricle of right valve; the anterior ear of right valve ornamented with coarse, simple radial ribs and raised commarginal growth lines.

Remarks: Even on internal moulds and fragments the tripartite fascicles are easily visible. This species seems to be one of the most important elements of the Upper Devonian bivalve fauna and probably one of the earliest species of the genus.

Occurrence: Autobahnknoten Langenhorst; Pilton Formation A.

Acanthopecten Girty 1903

***Acanthopecten?* sp.**
Pl. 2 Fig. 6, 16

Material: 6 internal, 7 external moulds, partly defective.

Description: Shell small, outline pectiniform, acline, transversely oval; ears small, flattened, nearly equal in length, well marked off from central body of shell by narrow sulci; umbos small, not raised above hinge margin. Central body of shell folded in 8 regular radiating plicae and sulci which do not increase in number but continuously increase in breadth and height ventrally; sulci narrower than plicae; both, plicae and sulci additionally covered with very minute radiating riblets (6-8 each); intersections of riblets and growth lines elevated as minute spines; posteriormost part of shell very slightly inflated, without radial folds and covered with about 10-15 thin, radiating, spiny ribs; ornament of ears usually reticulate.

Remarks: The gross appearance of the specimens is similar to modern pectinids, especially the folding of the central body of the shell. Comparable forms have not been reported from Devonian or Dinantian sediments of Central Europe, the only related species seems to be *Acanthopecten latiplicatus* Muromceva & Turbanov 1974 from the Lower Tournaisian of the USSR. Also, the generic assignment to *Acanthopecten* is doubtful as *Acanthopecten* is characterized by radial ribs rather than radial folds of the complete shell. Comparable shell morphology occurs in *Deltopecten* Etheridge jr. 1892 and *Undopecten* Waterhouse 1982 both known from the Permian, but as long as details of the ligament and hinge of the studied specimens are unknown a precise assignment is not possible.

Occurrence: Autobahnknoten Langenhorst.

Streblopteria McCoy 1851

***Streblopteria piltonensis* (Whidborne 1897)**
Pl. 2 Fig. 11-13

Synonymy: See Amler *et al.* 1990: 51.

Material: 13 internal, 10 external moulds.

Description: Shell small; outline subcircular, opisthocline; valves very slightly inflated; hinge margin short, straight; posterior ear short, triangular, very indistinctly separated from body of shell, posterior margin of ear very gently convex, confluent with posterior margin of body of shell and forming an obtuse angle with the posterodorsal margin; anterior ear longer, triangular, separated from body of shell by a shallow sulcus, anterior margin slightly convex; anterior and ventral margins of central body of shell confluent and regularly rounded; umbos small, pointed, hardly raised above hinge margin. Surface of shell nearly smooth except of very faint commarginal lines of growth; anterior ear of right valve ornamented additionally with few weakly developed radiating ribs.

Remarks: *S. piltonensis* seems to be one of the first, if not the very first, species of the genus which is widespread in the Carboniferous and Permian.

Occurrence: Autobahnknoten Langenhorst; Pilton Formation A.

Euchondria Meek 1874

***Euchondria vera* Drevermann 1902**
Pl. 2 Fig. 8-10

Synonymy: See Amler *et al.* 1990: 51.

Description: Shell small, acline or slightly opisthocline; outline transversely oval; hinge margin long, straight; ears of nearly equal size, relatively long, separated from central body of shell by narrow, deep sulci; anterior ear of right valve anteroventrally bounded by a V-shaped byssal notch; posterior ear triangular with slightly concave posterior margin; umbos small, proximate to hinge margin; umbonal angle about 120°; central body of shell very slightly inflated; distinct oblique ridge extending from umbo to central part of posterior margin; ventral margin moderately rounded, posterior and anterior margins more convex. Hinge margin crenulate from front to rear. Surface of shell nearly smooth on right valve; posterior ear with sharply raised commarginal lines, anterior ear with growth lines and six thin, radiating ribs; ornament of left valve composed of numerous delicate radiating ribs and very minute growth lines.

Remarks: Drevermann (1902) described two species of *Euchondria, E. vera* and *E. beushauseni,* from the Etroeungt of the Velbert area, the second of which is only partly known. Further studies are necessary to decide whether both species are synonyms or not.

Occurrence: Autobahnknoten Langenhorst; Bergisches Land.

Pernopecten Winchell 1865

***Pernopecten* sp.nov.**
Pl. 2 Fig. 3

Material: 3 internal, 2 external moulds.

Description: Shell of medium size, outline acline, suboval; very gently inflated; left valve with small but well developed triangular, acute ears, extending above straight hinge margin; umbos small; central body of shell bounded by two shallow sulci, diverging from umbo ventrally with about 80° and separating off two narrow, flattened, marginal areas of shell; median body of shell and anterior marginal area ornamented with about 20 simple radiating ribs; posterior marginal area smooth; radial ornament crossed by delicate growth lines; ears smooth or covered with minute growth lines.

Remarks: Whidborne (1897) described one species, *P. insperatus,* from the Pilton Beds of South England based on badly preserved material which seems to show a smooth surface without radial ornament. No other species of *Pernopecten* is known from the Upper Devonian or has been discovered because right valves are often indistinguishable from certain aviculopectinids as they lack the protruding ears typical for the genus.

Occurrence: Autobahnknoten Langenhorst.

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PLATE 1

Bivalves from the uppermost Devonian of the Velbert Anticline

1 : *Palaeoneilo lirata* (Phillips 1841).
Right valve, internal mould; ET.Wa1212, Coll. Thomas; x6,5.

2 : *Palaeoneilo* cf. *emarginata* (Conrad 1841).
Left valve, silicone cast of external mould; ET.Wa1332, Coll. Thomas; x3.

3 : *Leptodesma (Leptodesma) cultellatum* Whidborne 1897.
Left valve, silicone cast of external mould; Coll. Wehking; x4,25

4 : *Leptodesma (Leptodesma) anatinum* Whidborne 1897.
Left valve, external mould; KW.VLA32, Coll. Weber; x3.

5 : *Leptodesma (Leptodesma)* cf. *eberti* (Frech 1891).
Left valve, internal mould; Coll. Paul; x3.

6 : *Actinodesma (Actinodesma) angulosa* (Whidborne 1897).
Right valve, silicone cast of external mould; KW.VLA19, Coll. Weber; x3,75.

7 : *Leptodesma (Leptodesma)* cf.*anatinum* Whidborne 1897.
Left valve, silicone cast of external mould; KW.VLA10, Coll. Weber; x2,5.

8 : *Newellipecten? austeni* (F.A. Roemer 1855).
Left valve, silicone cast of external mould; SW1230, Coll. Wehking; x3.

9-10 : *Pterinopecten mundus* Whidborne 1897.
9 : Left valve, silicone cast of external mould.
10 : Left valve, silicone cast of internal mould, photographically reversed.
SW360, Coll. Wehking; x2,4.

11-12 : *Pterinopecten polytrichus* (Phillips 1841).
11 : Left valve, silicone cast of external mould.
12 : Left valve, silicone cast of internal mould, photographically reversed.
ET.Wa923, Coll. Thomas; x1,14.

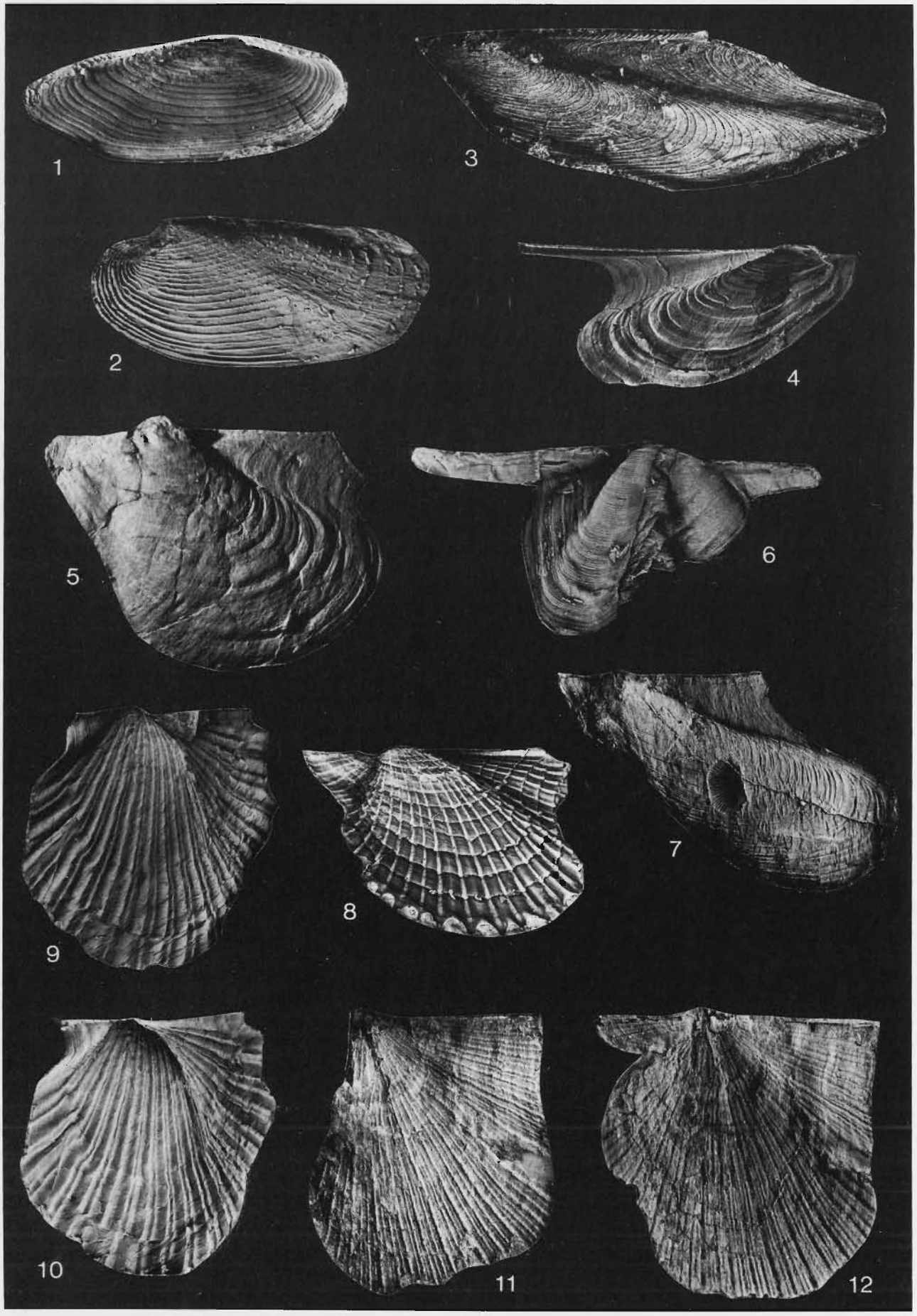
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PLATE 2

Bivalves from the uppermost Devonian of the Velbert Anticline

1-2 : *Fasciculiconcha transversa* (Sowerby 1840).
1 : Left valve, silicone cast of external mould; KW.VLA14, Coll. Weber; x1,7.
2 : Right valve, silicone cast of external mould; ET.Wa785, Coll. Thomas; x1,6.

3 : *Pernopecten* sp. nov.
Left valve, internal mould; KW.VLA11, Coll. Weber; x1,45.

4-5 : *Aviculopecten* cf. *nexilis* (Sowerby 1840).
4 : Left valve, silicone cast of external mould; ET.Wa466, Coll. Thomas; x2,6.
5 : Right valve, silicone cast of external mould; KW.VLA31, Coll. Weber; x1,45.

6 : *Acanthopecten?* sp.
Right valve, silicone cast of external mould; KW.VLA53, Coll. Weber; x5.

7 : *Aviculopecten? halli* (Whidborne 1897).
Left valve, silicone cast of external mould; KW.VLA44, Coll. Weber; x5,5.

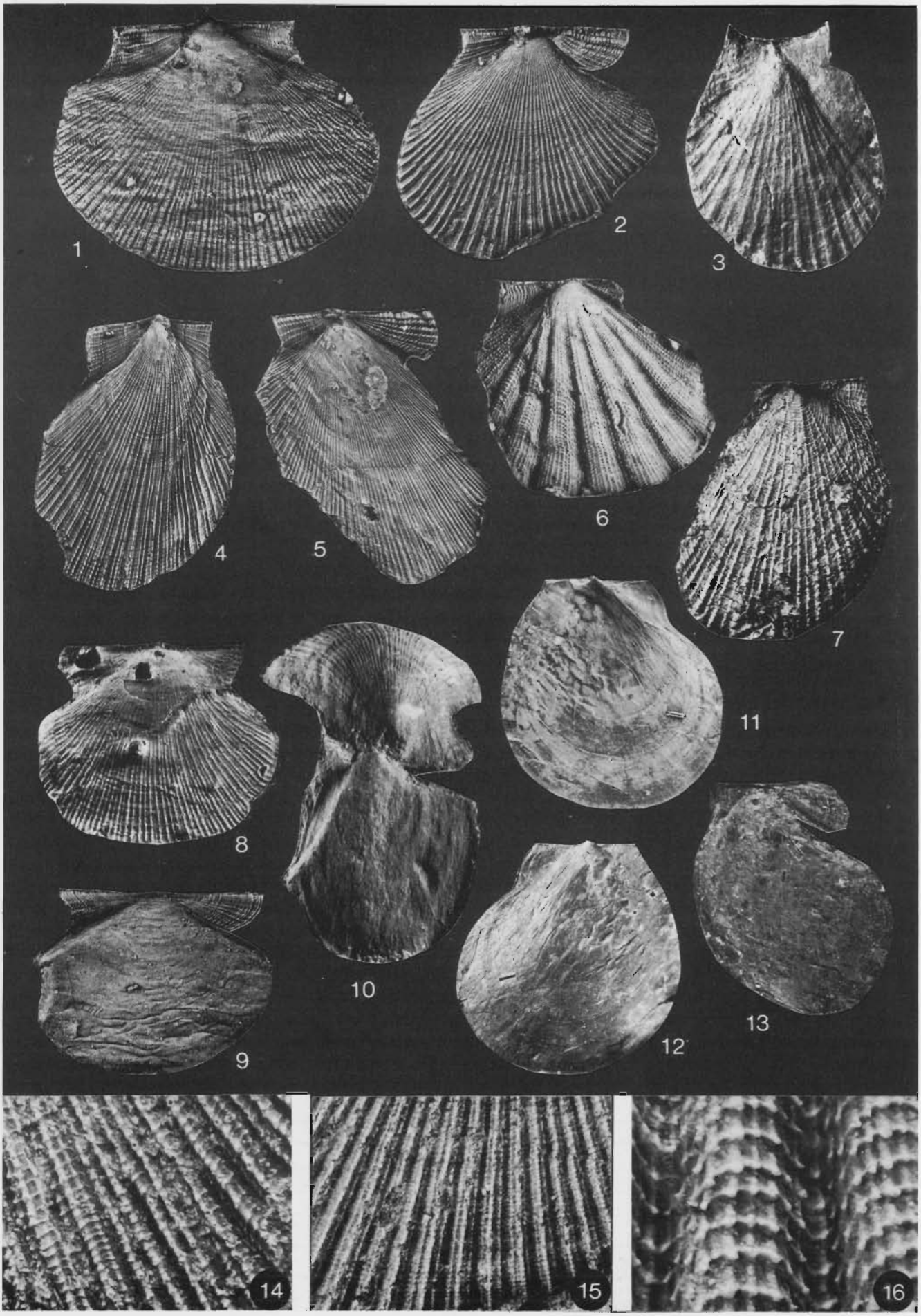
8-10 : *Euchondria vera* Drevermann 1902.
8 : Left valve, internal mould; ET.Wa415, Coll. Thomas; x3,4.
9 : Right valve, silicone cast of external mould; KW.VLA34, Coll. Weber; x4,2.
10 : Articulated specimen with left valve (top) and right valve (bottom); Coll. Paul; x2,5.

11-13 : *Streblopteria piltonensis* (Whidborne 1897).
11 : Left valve, external mould; KW.VLA66, Coll. Weber; x2,5.
12 : Left valve, internal mould; KW.VLA66, Coll. Weber; x2,5.
13 : Right valve, internal mould; ET.Wa1334, Coll. Thomas; x3,8.

14 : *Aviculopecten* cf. *nexilis* (Sowerby 1840).
Detail of exterior surface ornament; right valve, silicone cast; same specimen as Pl.2; Fig. 5; x6.

15 : *Fasciculiconcha transversa* (Sowerby 1840).
Detail of exterior surface ornament; right valve, silicone cast; same specimen as Pl. 2 Fig. 2; x3,8.

16 : *Acanthopecten?* sp.
Detail of exterior surface ornament; right valve, silicone cast; same specimen as Pl. 2 Fig. 6; x16.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