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Some Famennian (Upper Devonian) ammonoids from north western Europe

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Summary of Thesis submitted for Ph. D. degree

by J.D. Price

on

Some Famennian (Upper Devonian) ammonoids from north western Europe.

Famennian (Upper Devonian) ammonoids and their biostratigraphy are reviewed, with particular reference to the Sauerland and Oberfranken, West Germany. Most european species of the Order Clymeniida are described. The Famennian ammonoid zonal scheme is rationalised and within it 23 faunal levels are proposed. Ammonoid zones and conodont zones are correlated, and the *rhomboidea* (conodont) Zone is newly recognised to be coeval with the *curvispina* Zone. The following genera and subgenera are dealt with in detail: *Progonioclymenia*, *Endosiphonites*, *Sellaclymenia*, *Biloclymenia*, *Gonioclymenia* (*Gon.*), *Gonioclymenia* (*Kalloclymenia*), *Sphenoclymenia*, *Platyclymenia* (*Plat.*), *Plat.* (*Pleuroclymenia*), *Plat.* (*Trigonoclymenia*), *Sulcoclymenia*, *Piriclymenia*, *Ornatoclymenia*, *Cyrtoclymenia*, *Protactoclymenia*, *Carinoclymenia*, *Clymenia*, *Protoxyclymenia*, *Kosmoclymenia*, *Genuclymenia*, *Cymaclymenia*, Genn. Nov. *D*, *E*, and *F*. In most cases the types of the type species are illustrated photographically for the first time. The following generic names are recognised to have been wrongly interpreted in the past, and, where necessary new names have been proposed: *Kalloclymenia*, *Biloclymenia*, *Rectoclymenia* and *Falciclymenia*. Two new subgenera and one new genus are proposed, and two generic names, *Protactoclymenia* and *Endosiphonites*, have been revived. *Kosmoclymenia* is split into four species groups by its ornament and *Cymaclymenia* has been split into three species groups. Two widely used specific names are recognised to have been placed in the wrong genus; *sedgwicki* Münster is a *Pseudoclymenia* (a goniatite), and *serpentina* Münster is a *Protoxyclymenia*.

Volume 1

George, Count of Münster (1779-1844)

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Summary

This study of the taxonomy and stratigraphy of Famennian (uppermost Devonian) ammonoids in western Europe arises out of an NERC funded research project entitled "Devonian Ammonoid Stufen of the Rheinisches Schiefergebirge". Material was collected from the condensed cephalopod limestones of the Sauerland and Oberfranken.

All of the accessible museum specimens described in the literature during the last 150 years, especially those in the collections of Graf Münster, were examined and are illustrated here photographically for the first time.

Chapter 2 details the history of study of Famennian ammonoids, both in western Europe, and the rest of the world.

In Chapter 3 there is a critical view of all the ammonoid zonal schemes proposed for the Famennian, pointing out any discrepancies observed. The work of Wedekind (1908) and Schindewolf (1937a) is particularly important here, for the lower and uppermost part of the succession. The data presented in this thesis supplements the lower records and attempts to fill the gap in the sequence which has not been subject to precise study before. The nine ammonoid zones widely used in the Famennian are objectively defined, for the first time. A coherent series of 23 faunal levels are newly recognised within the Famennian.

A detailed review of the development of the classification of the Order Clymeniida is presented in Chapter 4. The scheme of Ruzhencev (1957), subsequently modified by Bogoslovskiy (1960-81) and Weyer (1981) is used. However, the Platyclymeniidae and the Biloclymeniidae are newly subdivided, and subfamilies proposed (Textfig. 4.4). The distinctive sutures of all clymeniid genera are illustrated (Textfigs. 4.6-16). Comments are passed on evolution within the Order, and Schindewolf's theory for the

origin of clymeniids is endorsed.

Systematic descriptions, principally of species introduced by Münster, comprise the whole of Chapter 5. Type specimens are newly recognised or proposed for nearly all species. Fossils are illustrated in forty-two photographic plates, and sutures, growth-lines and cross-sections are presented in 16 Textfigures. Measurements from each species are presented graphically, as a means of distinguishing and defining them.

The important parts of the systematic descriptions will be highlighted. *Progonioclymenia* (*Prog*.) *aegoceras* and *Prog*. (*Prog*.) *acuticostata* are recognised as separate species, with authorship of the latter being credited to Münster. *Endosiphonites* is recognised as a valid generic name, and is divided into two subgenera, including *Costaclymenia*. *End*. (*Cost*.) *binodosa* and *End*. (*Cost*.) *kiliani* are recognised as separate species; a neotype is proposed for the former. The species *bowsheri* Miller and Collinson is placed within this genus, rather than *Falciclymenia*. *Biloclymenia* is newly recognised as the senior synonym of *Kiaclymenia*, and its type species is *laevis* Richter, rather than *bilobata* Münster. A new name is required for *Biloclymenia sensu auctt*.

All of Münster's gonioclymeniid species are discussed, but few names can be associated with type specimens. *Otoclymenia* is recognised to be a junior synonym of *Gon*. (*Kalloclymenia*), and species without a ventral groove and parabolic growth-lines are accommodated within two new subgenera, one (*A*) including those species with a strong spinose ornament. Records of *Gon*. (*Kalloclymenia*) from the *Clymenia* Stufe are confirmed, and the entry of *Gon*. (Subgen. Nov. *A*) *brevispina* is used to mark the *Clymenia*-*Wocklumeria* Stufe boundary.

The new subfamily Platyclymeniinae is proposed to include Platyclymenia and related genera with simple sutures. The type species of Platyclymenia, annulata, is redefined in the sense of the original illustrations of Münster, using material from Oberfranken. Clymenia densicosta Frech is recognised as a synonym. Specimens from the Rheinische Schiefergebirge, widely referred to as annulata, are included within the species richteri Wedekind.

The morphology of the many species of Platyclymenia is reviewed. Whorl shape and ornament are analysed graphically, and the results confirm the validity of the morphological criteria by which Platyclymenia is divided into subgenera.

The genera Sulcoclymenia, Piriclymenia and Ornatoclymenia are included within a newly proposed subfamily.

The simple sutured subinvolute or involute clymeniid genera Cyrtoclymenia and Rectoclymenia are subjected to major revision based on an analysis of growth-line shape. Rectoclymenia itself is recognised as an invalid name and Gen. Nov. D is proposed to replace it. It is restricted to containing those species with radial growth-lines. A new genus, E, is proposed to replace Falciclymenia sensu lato, because this, when interpreted strictly, must be treated as a goniatite. A new genus, F, is erected to contain species with prorsiradiate growth-lines, formerly included within Cyrtoclymenia or Rectoclymenia. Gen. Nov. F also has a suture with a weak ventral lobe.

Clymenia itself is considered to date from 1831. Species within the genus can be distinguished graphically. The species serpentina Münster is newly recognised to be a Protoxyclymenia.

A neotype is proposed for undulata, the type species of Kosmoclymenia. Kosmoclymenia is newly divided into four species groups, according to growth-line shape and ventral ornament. These are: I, species with biconvex growth-lines and a ventral band; II, species with biconvex ornament, lacking a ventral band; III, species with strongly biconvex ornament, ventro-lateral grooves and a rounded keel developed at relatively large diameters; IV, small species with prorsiradiate weakly biconvex growth-lines, strong ventro-lateral grooves, and a tabulate venter. The species *bisulcata*, long wrongly interpreted as a species now recognised as belonging in Group IV, is included in Group III. The distinctive ventral ornament of species in Group I is described, and is shown to vary between isolated spinnaker-shaped spines and continuous paired ventro-lateral flares, joined by projections from the venter.

The species *sedgwickii* Münster, long included within this genus, is recognised to belong in *Pseudoclymenia*, which is a tornoceratid goniatite.

The type species of *Cymaclymenia*, *striata*, is redefined by reference to type material and original illustrations. Thus interpreted it is considered to be not synonymous with the usage of other authors this century.

Cymaclymenia is split into three species groups by growth-line shape and ornament: *striata* Group, *dorsocostata* Group and *costellata* Group. Species can be distinguished graphically.

Dorsal wrinkle-layer is described in *Biloclymenia*, *Platyclymenia*, *Carinoclymenia*, *Kosmoclymenia* and *Cymaclymenia*, and ventral wrinkle-layer was also observed on these last two named. Dorsal wrinkle-layer in clymeniids is radially directed, consisting of anastomosing lirae. Dorsal wrinkle-layer is expressed as pits on internal moulds.

Chapter 6 critically reviews the correlation between the ammonoid and conodont zonal schemes. Particular attention is paid to those sections from which both ammonoids and conodonts have been collected. Generally the correlation presented by

Klapper and Ziegler (1979) is confirmed but this (and references contained therein) lacked detailed substantiating evidence. This is presented here, together with new data relating to particular critical parts of the sequence, summarised in Textfig. 6.3. The *rhomboidea* Zone is correlated with the *curvispina* Zone, rather than the *pompeckji* Zone.

Details of all collecting localities are given in Chapter 7, together with faunal range charts for two important sections, Beil and Hövel. All specimens deposited in the collections of the University of Hull are listed.

Chapter 8 provides a short biography of Count Münster, and includes a bibliography of works dealing with Famennian ammonoids.

Chapter 1

Introduction

Introduction

In 1978, when this research was started, nothing had been written on the topic of Famennian ammonoids from western Germany since Schindewolf's (1937a) important account of the famous Oberrödinghausen railway-cutting section in the Hönnetal. This had been used since then as the reference section for the Devonian/ Carboniferous boundary. Schindewolf, in a series of articles published between 1916 and 1972 contributed much to knowledge of Famennian ammonoids, revising accounts of faunas from Oberfranken, which were the first Famennian ammonoids to be described, and adding considerably to the accounts of Wedekind (1908-1917) and Schmidt (1921, 1924) which dealt with faunas from the Sauerland.

Since the war palaeontological studies of the limestones in which Famennian ammonoids occur have been focussed on conodonts (Sanneman 1955, Ziegler 1962-73, Helms 1959-61), which can play a more useful role in biostratigraphy than coeval ammonoids, largely because of their greater abundance, and more widespread distribution, both geographically and facially.

An ammonoid zonation of the Famennian was developed during the first half of this century (Frech 1902, 1913; Wedekind 1908, 1913a,b, 1914; Schindewolf 1916, 1923a, 1937a) and a conodont zonation was established and correlated with it relatively recently (Ziegler 1962, 1971a,b; Sandberg and Ziegler 1973; Klapper and Ziegler 1979).

During the last twenty years Famennian ammonoids have been newly subjected to detailed taxonomic treatment in England (Selwood 1960), USSR (Bogoslovskiy 1955-81), northern Spain (Kullmann 1960), North Africa (Petter 1959,60), Australia (Petersen 1975) and North America (House 1962-78). For this work material has been collected from many of the localities studied by previous authors in

Germany. From reading the above listed accounts and studying my own material it became increasingly clear that the documentation of species described by previous workers, especially those from the last century, was woefully inadequate for correct and modern interpretation. This confirmed the opinion of Prof. M. R. House, who had established an NERC funded research project (see below) to look at this problem. Schindewolf (1923a) had gone some way to remedying this situation, but he unfortunately left a legacy of nomenclatural problems of his own making, and ambiguities, all of which he had not managed to correct by his death.

Aims of the thesis

This thesis aims to clarify and restate the definitions of some Famennian ammonoids. To this end many old collections have been sought and studied. The works of George, Count Münster are the first in which Famennian ammonoids were described and consequently great importance is to be placed on his collections. Much of these were destroyed during the last war, or have been lost over the last 150 years, so a previously unstudied Münster Collection, now divided between the British Museum and the Sedgwick Museum, Cambridge, was particularly important. Other collections were also searched for and documented, including Sandbergers' at Wiesbaden, Schindewolf's at Marburg, material used by von Buch, Frech, Schmidt and Schindewolf, now in the Museum für Naturkunde, Berlin, besides smaller collections in other museums. Unfortunately the bulk of Wedekind's material at Göttingen could not be made available for study, or was reported by the Curator as lost (Jahnke, pers. comm.).

A wealth of material was examined, but sufficient time was available to deal with the Order Clymeniida only. Documentation of the Famennian goniatites, especially the Cheiloceratidae, proved a difficult problem, both because most of the Sandbergers' Collection is in disarray, and because such apparently simple goniatites have relatively few morphological features by which they can be discriminated. Also there is little opportunity today in Germany to undertake precise collecting of these faunas. A description of the Cheiloceratidae awaits the attention of future authors.

Contents

Chapter 2 presents a history of the study of Famennian ammonoids. The classification, phylogeny and evolution of the Clymeniida are described in Chapter 4. Chapter 5 is devoted to systematic descriptions of the Clymeniida. Ammonoid zonal schemes are discussed in Chapter 3, and conodont zonal schemes are reviewed in Chapter 6, where some new data relevant to their correlation are presented. Details of collecting localities, sections and faunas are given in Chapter 7. Chapter 8 is a short bibliography of Count Münster. Copies of important and relatively inaccessible illustrations from 19th century publications are placed in an appendix.

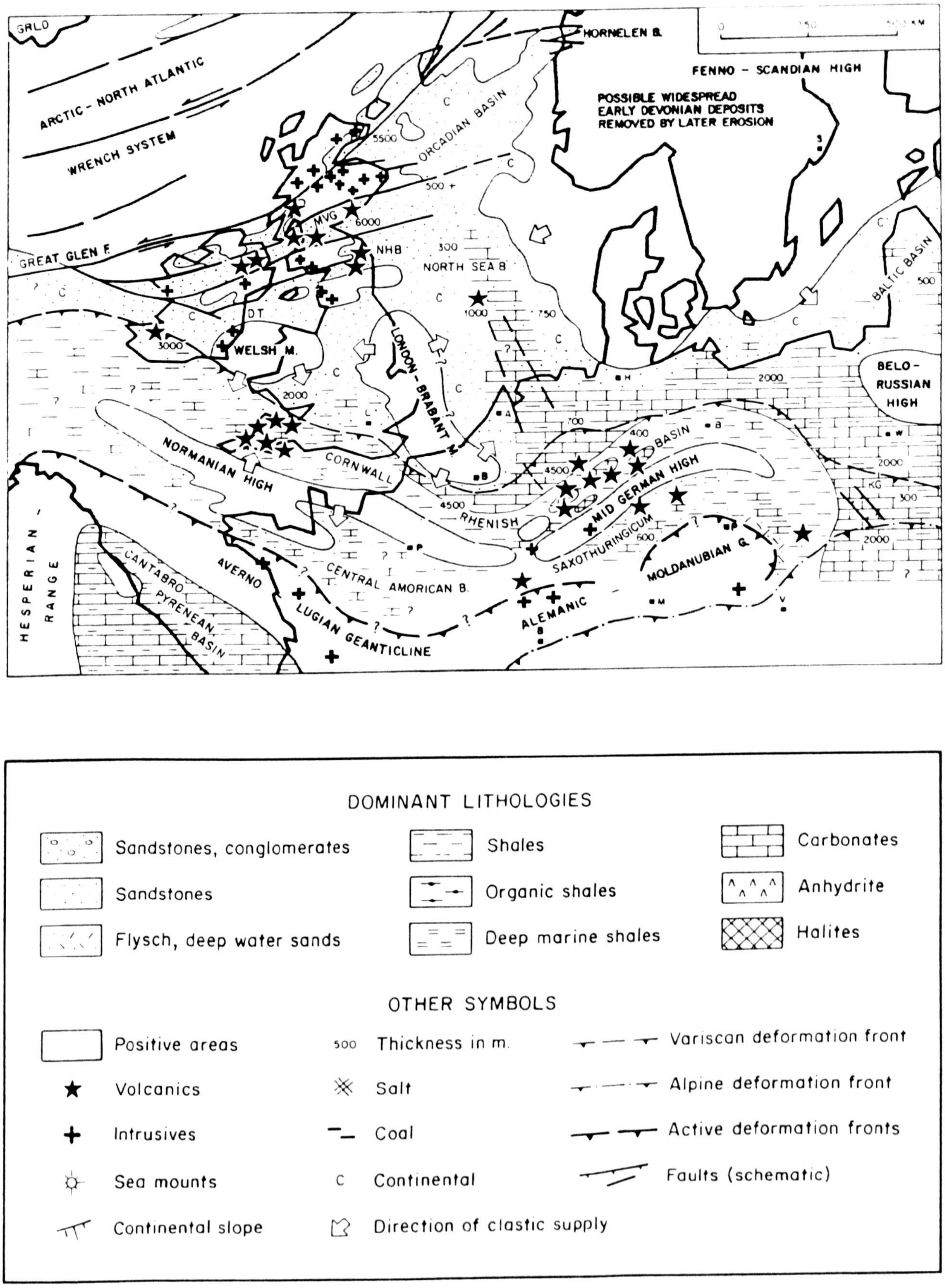
<u>Aims and outline of the NERC Project</u>

This thesis on Famennian ammonoids arises out of a project funded by NERC (GR 3/3250) entitled "Devonian Ammonoid Stufen of the Rheinische Schiefergebirge", itself aimed at improving the correlation between the existing ammonoid and conodont zonation of the Famennian in the Sauerland, West Germany. Earlier work nearby at Adorf (Textfig. 1.6; House and Ziegler 1977) had clearly demonstrated a mismatch in the two schemes for the Frasnian.

The project was to draw, in part, on the results of a thesis on the stratigraphy of the upper Devonian and lower Carboniferous of an area north east of Balve, Sauerland (Schäfer 1978), and on earlier work by Ziegler (1962, 1971a) in the same area. However, few sections or precise details of conodont samples were found to be available. Ziegler (1962) had published results of a section through most of the Famennian and into the lower Carboniferous, produced by road widening on the B515 at Oberrödinghausen, (now largely overgrown), and schematic sections of outcrops in the lower and middle Famennian at Beil, and in the upper Famennian at Hövel. Later (1971a) he published a more detailed section for Hövel and gave conodont zones for beds in the railway-cutting section at Oberrödinghausen, in which Paeckelmann (Jongmans and Gothan 1937) had defined the Carboniferous-Devonian boundary. Eickhoff (1973) published contradictory conodont zonal evidence for this section.

Schäfer's thesis contains details of at least 300 dated conodont samples, not all however were from the Famennian. Few were sufficiently accurately localised to enable collection of ammonoids from the same positions or horizons to be made. Under Schäfer's direction in November 1977 Sarah Gatley and Tony Beese, then post-graduate students at the University of Hull, collected ammonoids for this study from a trench through the lower Famennian at Beil, which was supplemented by material from the trench spoil, now in the collections at the Phillips University, Marburg. Later I collected material from the middle Famennian at Beil, Ainkhausen, and from the upper Famennian at Oese, Bilsteinhöhle, Dasberg, Hövel and Reigern (see Chapter 7 for precise details). A local amatuer collector, Dieter Korn, was instrumental in showing me numerous other localities where ammonoids could be collected, and he also loaned me many specimens.

Once I had begun to examine the material collected it became



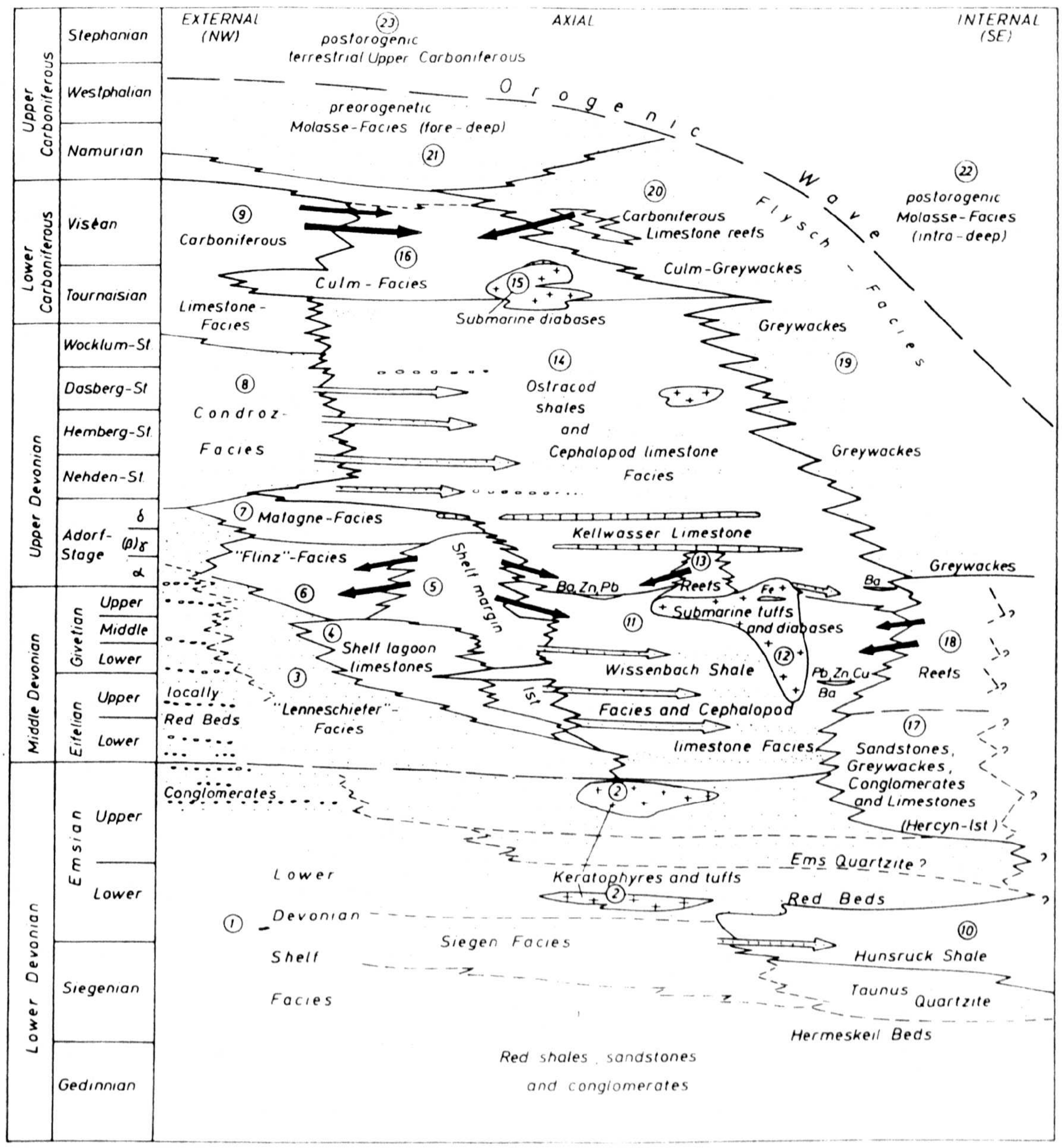
Textfig. 1.1 Mid- and Late-Devonian palaeogeography of north west Europe, from Ziegler P.A., 1981, fig. 5.

clear that literature relating to Famennian ammonoids was in dire need of revision, particularly that part dealing with species established by Count Münster. This thesis is the result of investigations to resolve this problem.

Geological Setting

Devonian Palaeogeography

Devonian sedimentation in north western Europe took place in a series of parallel belts which now run roughly east-west (Textfig. 1.1). Principal accounts, in which reference can be found to earlier authors, are by Erben and Zagora (1968), Krebs (1971, 1974, 1979), Meischner (1971) and Franke, Eder, Engel and Langenstrassen (1978). Good general treatment of the subject was provided by Matthews (1977) and P. Ziegler (1981). In the north west lay the Old Red Sandstone Continent, crossed by a series of mountain ranges the uplift and erosion of which provided detritus for the northern branch of the "Variscan Geosyncline", which lay in the south east. It comprised an inner and an outer shelf, characterised by terrigenous clastics and carbonates, respectively, with a predominately neritic fauna. Schmidt (1935) used the term "Rhenish" for this belt. Beyond the shelf lay the trough, characterised by shelf-derived turbiditic sandstones and limestones, shales and fine grained pelagic carbonates. This was termed the "Hercynian" Facies (Schmidt 1935). Later Schmidt (1952) interpreted the shales as being deposited in relatively unstable basinal areas (termed Becken) and the limestones to have been deposited on stable rises (termed Schwellen). Forming the southern margin of the trough was another shelf (the internal shelf of German authors) which lay against a narrow but laterally extensive island or chain of islands, the Mitteldeutsche Kristallinschwelle (Brinckmann 1948).



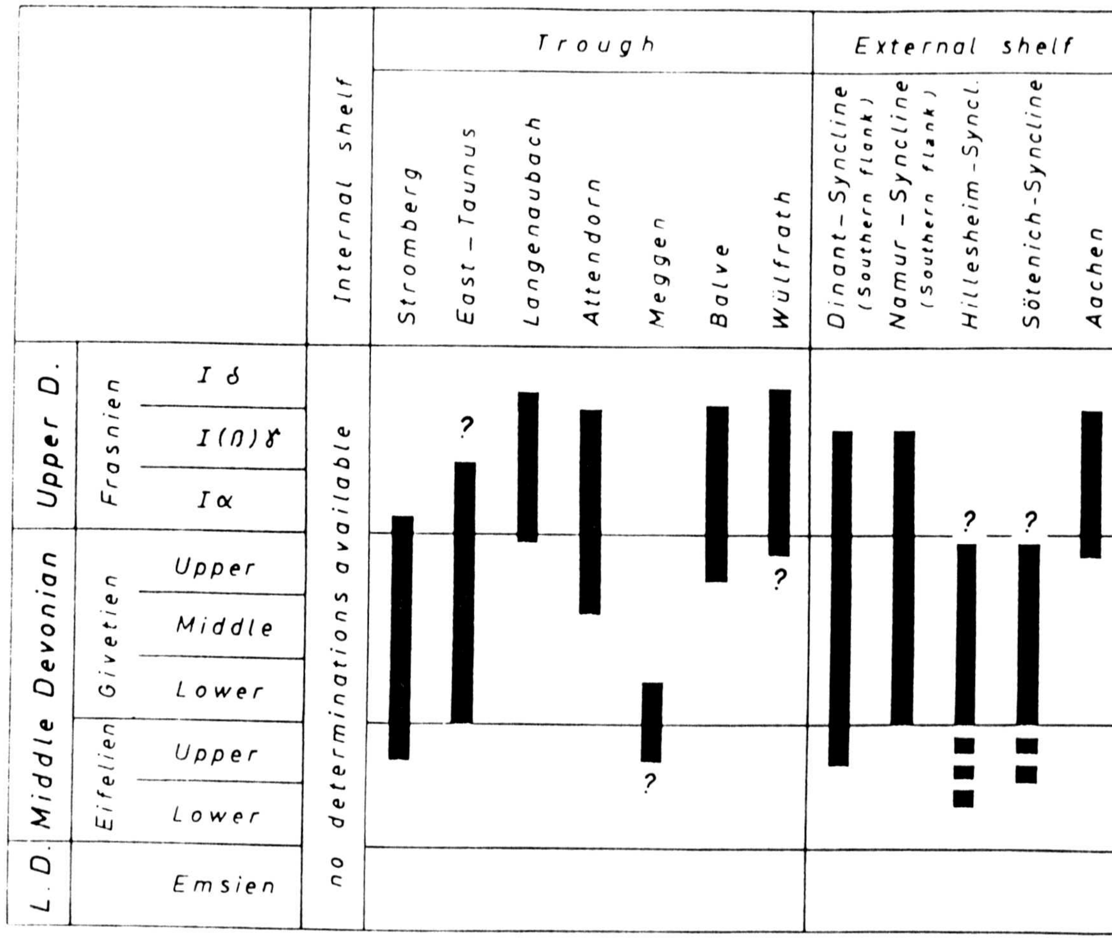
Textfig. 1.2 Diagrammatic cross-section through the Rhenohercynian fold belt of the Variscan geosyncline from Lower Devonian to Upper Carboniferous times. 1-9, external shelf; 10-16, basin; 17-18, internal shelf; 19-20, flysch; 21, pre-orogenic molasse; 22-23, post-orogenic molasse. Arrows with dots = sandstone turbidites; black arrows = limestone turbidites, from Krebs 1979, textfig. 1.

This is also referred to as the Middle German Island, Franco-Allemanic island etc., and was the source of detritus during the Famennian, but more importantly for the Visean-Namurian Variscan flysch.

This series of belts, affected by the Caledonian and Variscan Orogenies was termed the Rhenohercynicum (Kossmatt 1928) to distinguish it from the Saxothuringicum, in which there was a continuous undisturbed sequence from the Cambrian, which lay to the south of the Middle German Island. The group of belts comprising the Rheno-hercynian Zone can be traced running from Moravia through Silesia into the Harz Mountains, the Rheinische Schiefergebirge, across the Rhine in the Eifel, the Ardennes, and into southern England. Palinspastic reconstruction of the Iberian peninsula by closure of the Bay of Biscay, allows for a possible recognition of of this zone in southern Portugal (Franke et al. 1978). No satisfactory plate-tectonic explanation has been advanced for the sequence of events in the Variscan Geosyncline. Theories abound (see Vai 1973 for a review), ranging from a 1000km wide Rheic Ocean downwards, but none has achieved acceptance.

Upper Devonian Sedimentation

This thesis is concerned primarily with the Famennian ammonoid faunas of Germany, so some details of the development of sedimentation in this area during the Devonian are useful. During the lower Devonian large amounts of clastic material derived from the Old Red Sandstone Continent were deposited on a broad shelf, with black shales in the basin (Textfig. 1.2). The middle Devonian was marked by a considerable decrease in the supply of clastics, with fewer, better sorted sandstones and the widespread development of reefs. These began in the Givetian (Textfig. 1.2) and continued into the middle and upper Frasnian; actual dates of cessation



● Uppermost part of reef limestones

○ Uppermost part of detrital limestones

△ Lowermost part of pelagic limestones

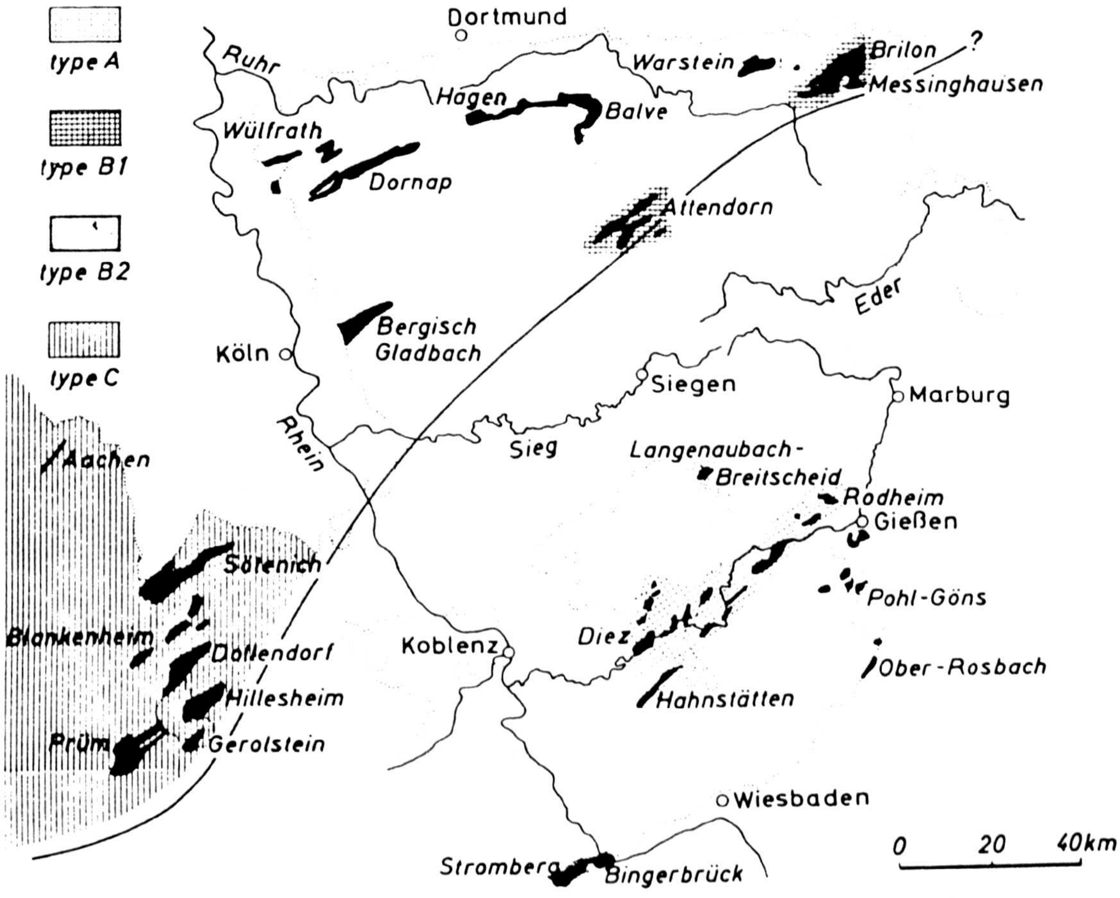
		Stromberg Syncline (MEYER 1970)	Osttaunus (WERDING 1965)	Rodheim (BENDER & BRINCKMANN 1969)	Langenaubach (KREBS 1966)	Attendorn (GWOSDZ 1969)	Brilon (BÄR 1966)	Dornap (BRINCKMANN 1963, KARRENBERG 1965)	Wülfrath (KARRENBERG 1965)	Aachen (KREBS & ZIEGLER 1965)	Iberg – Winterberg (KREBS 1963)
Upper Devonian I δ	Lower triangularis – zone								○		
	Upper gigas – zone			● △	● ○	△	● ○			○	●
I (β) γ	Lower gigas – zone					●					
	Ancyrognathus triangularis – z.					△	△	○			
	Upper asymmetricus – zone		●?								
I α	Middle asymmetricus – zone										
	Lower asymmetricus – zone	●						○			

Textfig. 1.3 Time-ranges and dates of cessation of reef-growth in the Rheinische Schiefergebirge, from Krebs 1974, figs. 6,7.

of growth are shown in Textfig. 1.3. Krebs (1971) recognised three main types of carbonate complex: Type A, atolls developed on volcanic rises (Lahn-Dill Syncline, Langenaubach-Breitscheid), Type B, shelf-atolls/banks, formed both at the shelf margin (Attendorn, Brilon), and within the shelf (Wülfrath - Dornap - Balve, and Bergisch Gladbach) and Type C, shelf lagoon carbonates (Eifel Mountains). The distribution of these complexes is shown in Textfig. 1.4.

The cause of the cessation of reef growth is problematic. During the Givetian and early Frasnian reef growth had been rapid enough to keep pace with subsidence, but when the subsidence rate increased the reefs would have drowned as organisms relying on photosynthesis were carried down, out of the photic zone (Meischner 1971). At odds with this explanation is recognition that two contrasting types of sedimentation took place at the sites of the dead reefs (Krebs 1974). Either rapid subsidence continued, and between 300 and 600 metres of Upper Devonian shales were deposited (e.g. Wülfrath), or subsidence almost ceased, and the reef-tops were subject to emergence and erosion, or slow deposition of cephalopod limestones (e.g. Lahn-Dill) while in the surrounding basins subsidence continued, and up to 700m of Upper Devonian shales were deposited. Therefore, in some cases reef emergence may have been responsible for the cessation of growth. Most of the reefs which continued to subside lie in the north west, and they mark a further stage in the continuing north-westward migration of the locus of deposition during the Devonian.

The upper Devonian was characterised by three types of sedimentation: reefs (Massenkalk), cephalopod limestones (Cephalopodenkalk), and pelagic ostracod shales (Cyridinen-Schiefer) (Textfig. 1.5). There were also periodic influxes of sandy turbidites derived from the shelf, deposited in the basins between the elevated



Textfig. 1.4 Distribution of carbonate complexes in the Rheinische Schiefergebirge, from Krebs 1974, fig. 5.

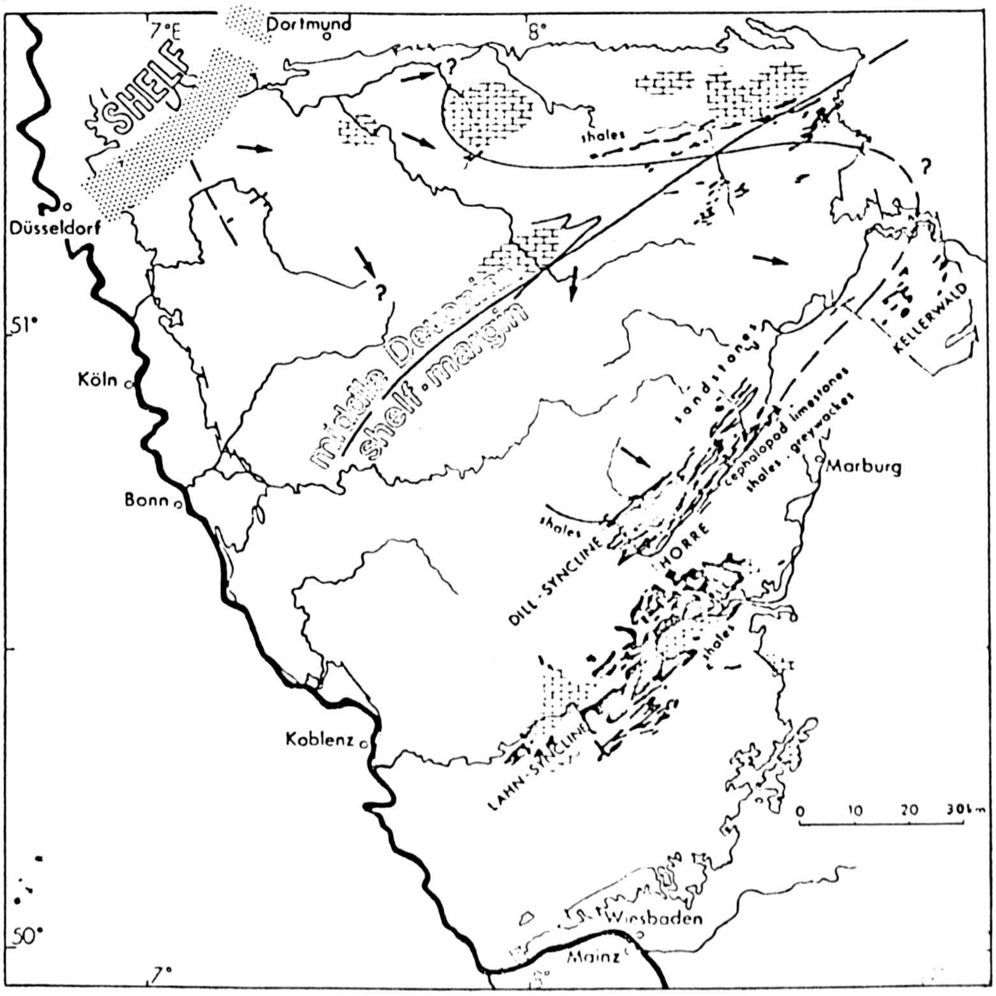
reefs. The Matagne Shale/Kellwasser Limestone is a unit which can be traced throughout central Europe, and marks a widespread upper Frasnian transgression. Similarly widely distributed black shales, marked by their high organic content, have been recognised during the Famennian (Annulata Shale, Hangenberg Shale). Similar depositional conditions continued into the lower Carboniferous.

Ammonoids in the Famennian of the Rheinische Schiefergebirge are restricted to three lithologies. Whilst they occur in the basin shales, occurrences are few and sporadic, and restricted to the widely recognisable Annulata and Hangenberg Shales (e.g. Oese). Black bituminous lower Famennian Nehden Shales, 10-20m thick with a haematitised fauna of goniatites, bivalves, gastropods and brachiopods, are found overlying parts of the atoll carbonate complexes at Bergisch Gladbach, Wülfrath, Brilon and Attendorn. Deposition took place under euxinic conditions in the former lagoon depressions, behind the reef rims.

Most widespread, however, are the condensed cephalopod limestones, situated over the dead reef complexes, Textfig. 1.5. These were the subject of a study by Tucker (1973b, 1974) and show the features described below. The shelf during the Famennian was restricted to an area north west of Essen, and is represented by a belt of sandstone shales, and locally developed carbonates. Ammonoids are known from Velbert (Paul 1939), and also from further west near Aachen (Wulff 1923, Kasig, Dreesen and Bouckaert 1979) and in the Dinant Basin (Dreesen 1982a,b).

Stratigraphy and nature of the Famennian Carbonates

Famennian ammonoids are found in large numbers only in the Schwellen (= rise) carbonates, termed Cephalopodenkalk. Two areas were studied, Balve and Warstein (Textfig. 1.4). In both upper Frasnian and Famennian limestones overlie submerged reefs of middle



Textfig. 1.5 Palaeogeography of the eastern Rheinische Schiefer-gebirge during the early Famennian (Nehdenian). Black, volcanics (Givetian to Visean); brick symbol, reefs (Givetian to Frasnian) preserved as rises on the sea-floor; white, shales, from Meischner 1971, fig. 4.

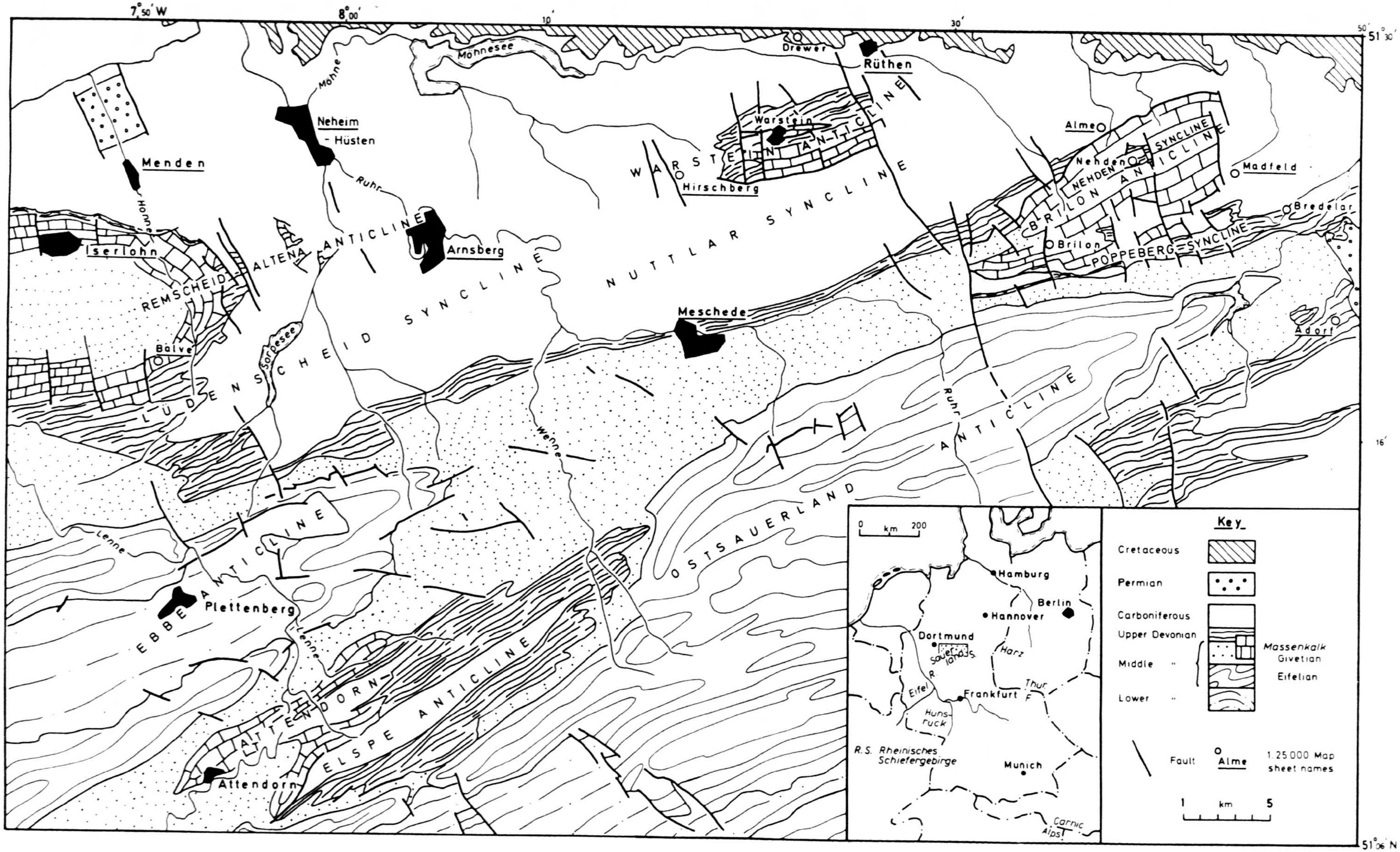
Frasnian age. The stratigraphy has been described in detail: Balve: Denckmann, 1901, Paeckelmann, 1924, Schmidt, 1924, Schäfer, 1978; Warstein: Schmidt, 1921, Clausen and Leuteritz, 1979; as have their ammonoid faunas: Balve: Wedekind 1910, 1913a,b, 1914, Schmidt, 1924, Schindewolf, 1937a, Clausen, Korn and Uffenorde, 1979. Recently Schäfer (1975, 1978) described in detail the immediate post-reefal evolution of the Balve area during the Famennian.

The condensed Schwellen rise carbonates, between 10 and 30m thick, are predominately red or grey-green, micro- or biomicrosparites. They show varying degrees of nodularity, determined by the original clay content, and have been affected by widespread solution resulting in clay-rich streaks and stylolites, to which German authors have applied the terms Kramenzel- and Flaser-kalk.

Away from the summit of the former rises more massive limestones pass into thicker nodular limestones (which may show slump features (Effenberg, Drewer, Plate 7.6a)), shales with calcareous nodules (Reigern, Plate 7.6b) and finally basinal shales (Cypridinenschiefer) with turbiditic sandstone and siltstone horizons (Oese), which can have a total thickness of ca 600m (Franke et al. 1978).

Most limestone sequences are incomplete, having been subject to erosion at some time before deposition of the uppermost Devonian Hangenberg Shales (e.g. Balve, Schäfer 1975), and are followed by a sequence of lower Carboniferous black shales, and cherts (Liegende Alaunschiefer, Lydit).

The fauna is almost totally lacking in benthos. In the shales only ostracods and thin-shelled posidoniid bivalves are known in abundance, both of which are interpreted as pelagic. The limestones contain a more diverse fauna including ammonoids, nautiloids, trilobites, conodonts, all of which are planktonic/nektonic, with arenaceous foraminifera and epibyssate bivalves, representing the



Textfig. 1.6 Geological map of the Sauerland and surrounding areas, after Kromberg, Pilger, Scherp and Ziegler 1960.

only true benthos. One factor which is difficult to explain satisfactorily is the absence of lamination in the limestones, supposedly (Tucker 1973a) the result of extreme bioturbation, although traces of burrows are difficult to find, and evidence of the burrows themselves is unknown.

Lithology

Most of the sections examined were developed in limestones, and precise details are given in Chapter 7. Generally the limestones of the Balve area, especially in the lower Famennian, are red in colour, weathering to green and yellow (e.g. Beil, Effenberg). Higher in the sequence they are buff, grey or grey-black (Hövel, Oberrödinghausen), weathering to a yellow-brown. The limestones are composed of at least 75% non-ferroan calcite, the rest being pyrite, quartz (silt grade), but chiefly clays. Skeletal material is relatively rare, especially in the lower Famennian. Few shell beds were recorded, but most ammonoid body chambers contain concentrations of ostracods and conodonts. Few sedimentary structures were observed, the most common being erosion surfaces and hard grounds. Ammonoids lying on a bedding-plane are frequently truncated, with the uppermost shell and internal septa removed, with the exposed surfaces now coated with haematite. Slumping in nodular limestones (Drewer, Bilsteinhöhle) is associated with sedimentation on the unstable rise slope. Compaction features are restricted to the less carbonate-rich rise slope/nodular limestones. This, together with the widespread occurrence of hardgrounds, is taken to indicate early lithification in the rise limestones.

Methods of Study

Collecting

Most collecting was done by conventional means. There were three methods of collecting, from outcrop (Beil, Malers Länder, Bilsteinhöhle; all localities are listed in Chapter 7), from deep mechanically dug trenches forming long sections (e.g. Beil), and from shallow trenches formed by removing the soil horizon with picks and spades (Beil, Hövel, Müssenberg, Dasberg). This latter method was used most frequently since there were few natural exposures in the Sauerland and deeper artificial trenches were too expensive to commission.

Preparation

Large rock samples were collected at most localities, in some cases up to 30 kg. from one horizon. This was because fossils were difficult to extract successfully in the field from hard limestones. Material was therefore broken down in the laboratory, either by heating it for a few minutes in a furnace at 800°C, and then chilling it in cold water, or with various mechanical crushers, vices, hammers etc. The isolated fossils were then prepared in a coventional way with small chisels, needles and a Burgess electric engraving tool. Fossils preserved as haematite or pyrite internal moulds were collected from surface exposures in shales or clays, or extracted from bulk samples by digesting the matrix in acetic or formic acids. The fossils were subsequently cleaned in the laboratory with abrasive powders (usually sodium carbonate) in a stream of compressed air, using an S. S. White air-abrasive jet machining unit, or suspended in water in an ultrasonic tank.

Fine detail, such as sutures, were prepared by polishing and cutting the specimens using a Diprofil portable cutting tool, a pattern-makers' milling unit. Cross-sections were prepared by sawing the specimens roughly in half and then polishing the cut surface with successively finer grades of carborundum powder. Museum specimens and types were cut in half, mounted in blocks of plaster of Paris and guided through a circular saw. A fine carborundum blade with a thickness of 0.25mm was used, thus minimising loss of material. Photographs were then taken of the polished surface under water, or, more often, acetate peels were taken after etching the surface in either 10% hydrochloric acid (limestones) or sulphuric or hydrofluoric acids (haematite).

Conodont samples were prepared in a standard way, the limestones being broken into pieces 3cm in diameter and digested for 24 hours in 10% formic acid. The washed residues were screened through three sieves (710µ, 250µ, 125µ) with the fractions caught in the last two being picked directly, or subject to heavy liquid separation using tetrabromoethane.

Illustration

Drawings were prepared of features such as ornament, growth-lines and sutures. In the case of large specimens these were traced directly onto Sellotape stuck over the feature on the fossil. The Sellotape was then stuck onto millimetre graph paper and the tracing enlarged to fill a piece of A4-sized paper using the grid-lines as a guide, or a Grant Projector. Finally the enlarged drawing was checked for accuracy against the original specimen. The alternative method, used for intricate or small (less than 10mm in length) features was to view the specimen through a grid-line graticule in a binocular microscope and then to draw the image on graph paper, making sure that at all times the visible surface lay at right-angles to the line of sight. This was facilitated by a series of reference marks drawn on the specimen. A drawing of appropriate magnification was then produced.

Specimens were photographed on various cameras. M. R. House permitted the use of his Leica system for a visit to Munich. Thereafter photographs were taken on a Leitz Aristophot bench camera with a variety of lenses but principally a 120mm Summar, and a Nikkormat FT3 camera with Vivitar or Nikon 55mm macro-lenses. Illumination was provided by a single bulb of 275 or 500 Watts directed from the top left, and light was reflected onto the back of the specimen with a single parabolic-type reflector made from white card. Such a simple method, in conjunction with a light-weight tripod and camera, enabled photographs of many type specimens to be taken in English and German museums. Specimens were prepared for photographing by coating firstly with a proprietary (Barlow's) photographer's negative opaque, and then with a sublimate ammonium chloride, to enhance shadow formation, and evenness of light reflectance, respectively. Very small specimens , less than 3mm in diameter, were photographed on a Cambridge 600 Stereoscan.

Terminology and abbreviation

The literature of ammonoid descriptions is littered with subjective terms, some of which were defined in the glossary in the Treatise (Moore 1957). However, many others remain ambiguous, and each author tends to add to the ambiguity by well-intentioned definition of his terms, which undoubtedly differ in some subtle way from other authors. I too will do this, and hope that the reader, before looking at the taxonomic descriptions, has read this preamble.

Further complication is introduced by reading descriptions in foreign languages where words do not always mean what they might seem. Thus the German quadrat should be understood as square, and not as the English quadrate, which may mean merely four-sided.

Textfig. 1.7 Morphological terms used in the descriptions of ammonoids

A-E,H,I Growth-line shape

A, strongly biconvex; B, biconvex; C, weakly biconvex; D, concavo-convex; E, concave; H, S-shaped; I, parabolic ribs.

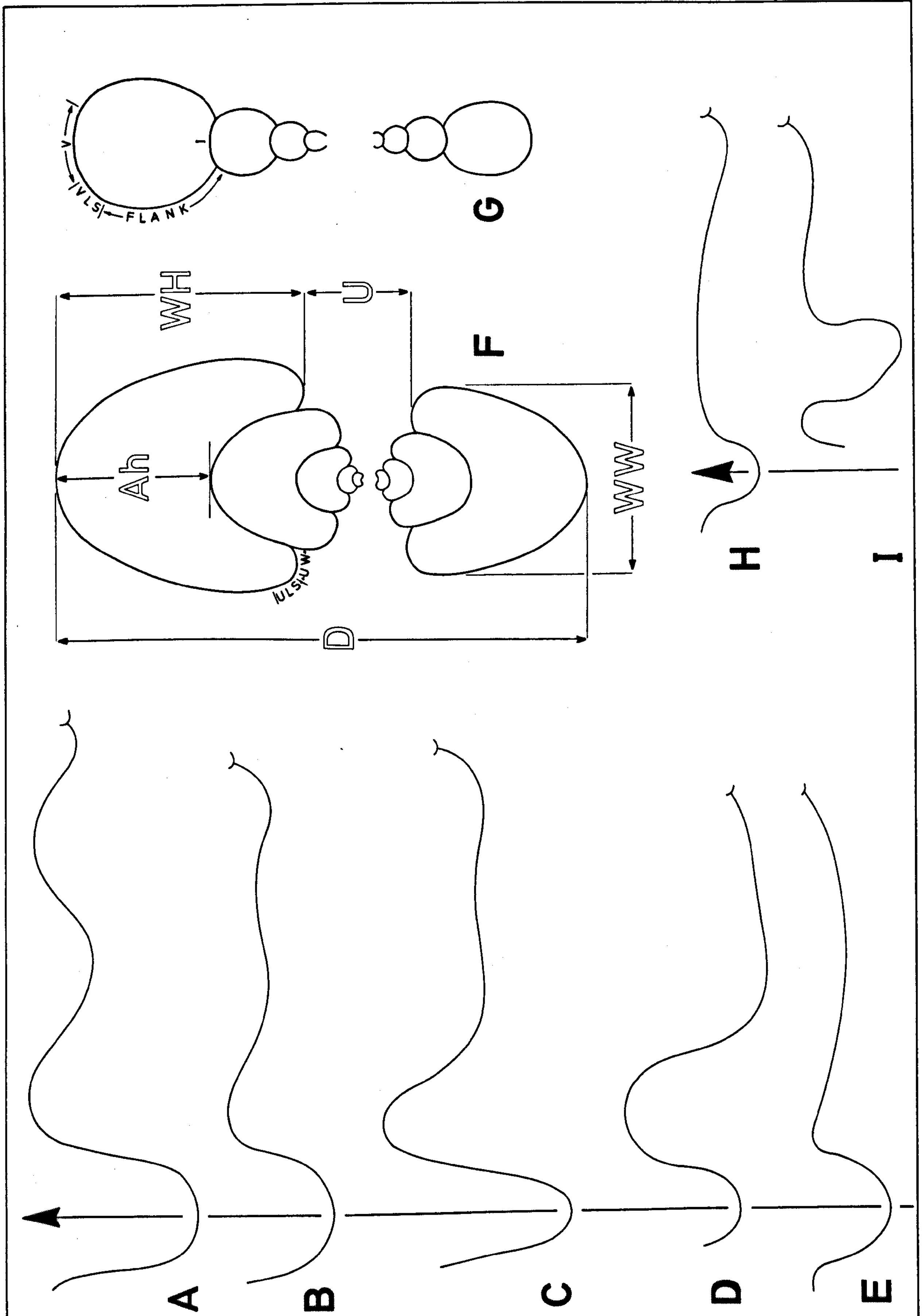
F Measured parameters

D, diameter; WW, whorl width; WH, whorl height; U, umbilicus; Ah, apertural height.

F,G Areas of the shell

V, venter; VLS, ventro-lateral shoulder; ULS, umbilical shoulder; UW, umbilical wall.

Textfig. 1.7



Shell shape: Form, coiling and evolution

The names given to various parts of the shell are shown in Textfig. 1.7. Some of these are the parameters measured and listed under the appropriate abbreviations in the section head "Dimensions" in systematic descriptions. In practice diameter and whorl width are easy to measure, provided that the specimen is complete with shell, lacks strong ornament (which introduces variation), and is undeformed. Accurate measurement of whorl height depends upon correct alignment of the callipers, and umbilical width is often the minimum distance between opposite umbilical walls, rather than the diametric distance between umbilical seams. Furthermore in involute and subinvolute specimens the umbilicus is often filled with matrix.

Shells are described as globose, discoidal or oxyconic. Discoidal is a much overused term, almost meaningless since it has been applied to all shell forms intermediate between globose (i.e. almost spherical) and truly disc-shaped (i.e. like a gramaphone record). Numerical limits have been arbitrarily imposed, based on the ratio WW/D:

Globose	>0.90
Subglobose	0.7-0.9
Thickly discoidal	0.7-0.5
Discoidal	0.2-0.5
Oxyconic	<0.2

Whorl cross-sections are termed depressed (WW>WH), compressed (WW < WH), circular (WW=WH), oval, and pear-shaped (subtriangular), with venters which are tabulate, grooved, bounded by ventro-lateral grooves, keeled, arched or carinate. Only serpenticonic or oxyconic coiling is mentioned specifically. Evolution is more difficult to define, there being a continuum between perfectly involute and evolute shells. Arbitrary numerical limits have been imposed, related to the ratio U/D (see below):

Evolute	>0.5
Subevolute	0.3-0.5
Subinvolute	0.1-0.3
Involute	<0.1

Growth-lines

Growth-line direction is referred to as prorsiradiate, radial or rursiradiate, according to the direction of a line running between the growth-line at the ventro-lateral and umbilical shoulders. Growth-line shape has been variously defined by authors. Here the terms used are concave, straight, convex, concavo-convex and biconvex, and qualified by "weakly" or "strongly", which are illustrated in Textfig. 1.7. Elements of the growth-lines are referred to by their position on the shell, i.e. ventral, lateral etc. and their shape as either sinuses or salients.

Growth-lines are described as lamellose or lirate, according to their cross-sectional shape.

Ornament

There is not a wide range of ornament types in Famennian ammonoids. Ribs are rare, and are described as strong, weak, or plicate when merely present as folds on the surface. Tubercles may be present at the ventro-lateral or umbilical shoulder, and can project laterally or ventrally and dorsally. Continuous ventro-lateral flares are known, as are spinnaker-shaped ventral spines. When broken-off their trace/base on the venter is referred to as the ventral band. Both growth-lines and ribs can have parabolic indentations resulting from resorption of shell material.

Sutures

The various genetic formulae used to describe sutures have been widely reviewed elsewhere (Kullmann and Wiedman 1970, Wiedmann and Kullmann 1980). The simpler, more readily understood system of Wedekind (1910, 1917), as modified by Wiedmann and Kullmann (1980) is preferred to that of Ruzhencev (1962) but neither is widely used in this thesis since the sutural ontogenies of most Famennian ammonoids, especially clymeniids, are still unknown, thus making a genetic terminology inappropriate. Instead a descriptive scheme is used, related to the position of the element in the whorl section. Terms used are ventral, ventro-lateral, lateral etc. Famennian ammonoid sutures are rarely complicated enough for ambiguity to arise.

Signs used in the synonymy lists

Introduction

In this thesis a system of signs placed before the date in the synonymy lists is used. They are commonly found in German literature, but are not frequently employed by English-language authors, and so an explanation is desirable. The system was developed by Richter (1948), and amended by Rabien (1954). This discussion draws freely on Matthews' account (1973), which has been used as the basis for a description of the scheme.

The purpose of the system is to amplify and qualify the information given in a synonymy list. Ideally the reference, plus signs, becomes self-evident, and little or nothing need be added in the "Remarks" section of a systematic description. At best the synonymy, when complete, provides all the bibliographic information about a particular species and enables the reader to assess at a glance the value of each and every previous reference, and much involved discussion can be eliminated from the text. At worst the system can be confusing, especially when not understood by the reader who accepts each entry as being of equal value.

The system

The way in which the date of a reference is presented is itself informative:

1921	The date in italics records the mere mention of a species, usually in faunal lists, and normally has not added to understanding of the species.
1923	A reference in normal type-face is one which has added to understanding of the species.
(1838)	Use of brackets indicates that the year of publication is uncertain.

All other signs precede the date of the reference:

*	An asterisk denotes the earliest legally valid description/mention of a species, from which the species is considered to date.
v	This is an abbreviation of "vidimus". The specimens cited in the reference (either as illustrations, or otherwise) have been examined.
p	This is an abbreviation for "partim". It means that the reference cannot now be accepted as applying exclusively to this species. Specifically excluded figures are generally indicated in this way: pl. VII, fig. 2,5, non figs. 3,4.
non 1908	Although a previous author believed that his material belonged to the species under discussion "non" denotes that this view is not accepted. There is always a discussion of this opinion, or at least, a reference to another author's views.
? 1923	The question mark indicates an opinion less doubting than the use of "non" would have done. It implies an objective assessment, based on an examination of the original material or good figures, or referring to a particular point in the description, and means this reference cannot definitely be accepted as belonging to

this species. Single figures in a reference can be qualified with a question mark.

(?) 1914 A question mark in brackets indicates a more subjective doubting of this reference. However, the material on which the previous author based his description may be lost, or his description ambiguous, and so the reference can never be excluded with certainty.

. 1927 The stop indicates that the author includes this reference on his own initiative.

Combinations of the signs can be employed, viz:

v* 1832 The type material has been examined.

vp 1923 The material used by the cited author in this reference has been examined, and only some specimens are considered to belong to the species under discussion.

pv 1923 Only some of the material used in the cited author's description has been seen.

vpv Only some of the cited author's material has been seen, and only some of this, or the figures referred to, are considered to belong to the species under discussion. Cited figures can be excluded/included by use of the signs, viz:

pl. V, figs. v6, ?7, (?)8; non 11.

v? The material inquestion has been examined, but cannot be excluded or included with certainty, usually because it is poorly preserved, or lacking in some diagnostic feature.

Signs are also used in the sections listing specific or generic names:

* An asterisk denotes the type species.

= The species name was an homonym, a new name has been substituted.

h The species name is newly recognised as an homonym.

s The species name is a synonym

Abbreviations of Generic Names

The following abbreviations are used throughout:

A.	Acanthoclymenia	Pina.	Pinacoclymenia
Acri.	Acriclymenia	Pl.	Planulites
Akt.	Aktuboclymenia	Plat.	Platyclymenia
Bil.	Biloclymenia	Pleur.	Pleuroclymenia
Car.	Carinoclymenia	Pn.	Protornoceras
Ch.	Cheiloceras	Post.	Postglatziella
Cl.	Clymenia	Postpro.	Postprolobites
Cost.	Costaclymenia	Prog.	Progonioclymenia
Cyma.	Cymaclymenia	Prol.	Prolobites
Cyrt.	Cyrtoclymenia	Prot.	Protactoclymenia
End.	Endosiphonites	Pro.	Protoxyclymenia
Epi.	Epiwocklumeria	Ps.	Pseudoclymenia
Falc.	Falciclymenia	Rect.	Rectoclymenia
Genu.	Genuclymenia	Sch.	Schizoclymenia
G.	Goniatites	Sell.	Sellaclymenia
Gl.	Glatziella	Sin.	Sinoglatziella
Gon.	Gonioclymenia	Sol.	Soliclymenia
Hex.	Hexaclymenia	Sp.	Sporadoceras
Kia.	Kiaclymenia	Sph.	Sphenoclymenia
Kall.	Kalloclymenia	Spin.	Spinoclymenia
Kosmo.	Kosmoclymenia	St.	Staffites
Lag.	Laganoclymenia	Sten.	Stenoclymenia
Lent.	Lenticlymenia	Sul.	Sulcoclymenia
M.	Manticoceras	Syn.	Synwocklumeria
Miro.	Miroclymenia	Torl.	Torleyoceras
Orn.	Ornatoclymenia	Tri.	Trigonoclymenia
Oto.	Otoclymenia	Ural.	Uraloclymenia
Pach.	Pachyclymenia	Var.	Varioclymenia
Para.	Parawocklumeria	Wock.	Wocklumeria

Museums:

Abbreviations used for museums can be found below under the section headed Acknowledgements.

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Curators from various institutions have kindly answered inquiries or loaned specimens for this study:

BM	British Museum (Natural History), London, (D. Phillips, Dr. M. K. Howarth)
BSP	Bayerische Staatssammlung für Paläontologie und historische Geologie, Munich, (Drs. R. Förster, G. Schairer)
BU	Geology Department, University of Bristol, (M. White)
FMW	Fuhlrott-Museum, Wuppertal, (Dr. C. Brauckmann)
GOT	Geol.-Pal. Institut u. Museum, Göttingen, (Dr. H. Jahnke)
GSM	Geological Survey Museum, Inst. Geol. Sciences, London, (Dr. R. Butler)
HU	Geology Department, University of Hull
Mbg	Geol.-Pal. Institut, Marburg, (Dr. G. Kauffmann)
MfN	Museum für Naturkunde, Berlin, (Drs. J. Helms, H. Jaeger)
NWGL	Geologisches Landesamt NRW, Krefeld, (Drs. E. Paproth, C.-D. Clausen)
RE	Ruhrland- Museum, Essen, (Dr. K. Kilpper)
SM	Sedgwick Museum, Cambridge, (Dr. C. Forbes, M. Dorling)
SMF	Senckenberg-Museum, Frankfurt, (Dr. R. Werner)
SMM	Städtisches Museum Menden, (H. Hoffmann)
UEN	Geologisches Institut, Universität Erlangen-Nürnberg

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Angela Warren devoted much time to improving my rather fossilised style of English, and to typing this thesis, and thus deserves all my thanks and gratitude.

Chapter 2

A history of the study of Famennian ammonoids

The First Forty Years (1831 - 1871)

Knowledge of Famennian ammonoids dates from 1831 when two short papers by Georg, Count Münster, were delivered to the Geological Society of France. These described the distribution of "ammonées" and "nautilacées" in Germany (Münster 1831, p. 173 - 85). Münster recorded ten species of Goniatites and eight species of Ceratites from the "Uebergangskalk" of the Fichtelgebirge in north eastern Bavaria. These taxa, sub-divisions of the genus Goniatites de Haan 1826, followed the usage of Leopold von Buch, established in two lectures he had just delivered to the Königliche Akademie der Wissenschaften, Berlin. These lectures were milestones in the development of the classification of ammonoids. Goniatites was defined as having simple lobes and saddles and was completely involute; Ceratites differed from it by being evolute. Both could be distinguished from Nautilus by the position of the siphuncle, which was ventral in Goniatites and Ceratites, and mid-way between the dorsum and the venter in Nautilus. Further attempts to divide the ammonoids into "families" were made by Beyrich (1837) and Sandberger and Sandberger (1850-56).

Münster mentioned two species by name: G. speciosus (1831a, p. 177) from Heinersreuth, which was described as resembling Ammonites Conybeari Sowerby 1812; and Planulites laevigatus (1831b, p. 182), which had an "open shell 7 inches in diameter with a smooth test and 8 whorls". This latter species was listed with the Nautilacées without further explanation, and was considered the most common in the Fichtelgebirge. Both of these descriptions were amplified in Münster's pioneering work on Famennian ammonoids "Ueber Planuliten und Goniatiten im Uebergangskalk des Fichtelgebirge" (Münster 1832). Forty two species of Goniatites and Planulites were described, most of which have survived into today's literature, and at least ten have become the type species of modern genera. Planulites was distinguished from the Goniatites by the dorsal position of its siphuncle.

Earlier in 1832 Leopold von Buch had published an account of a lecture on goniatites, given on the 15th December 1830 to the Akademie in Berlin. This contained brief and ambiguous descriptions and figured a few goniatites and clymeniids from the Fichtelgebirge which von Buch had been sent by Münster. Von Buch did not notice the characteristic position of the siphuncle in the clymeniids.

In 1833 Münster announced his intention to have "Ueber Planuliten und Goniatiten ..." translated into French (Münster 1834a) and, at the same time, to replace the name Planulites with Clymenia, derived from the Greek Clymene, daughter of Oceanus, since Planulites Parkinson 1822 was in fact an annelid. The translation, "Mémoire sur les Clymènes et les Goniatites ..." appeared in 1834 (Münster 1834b). Münster (1833) also published a catalogue of his extensive collection of fossils.

In 1835 Münster wrote a letter to the Neues Jahrbuch in which he used the name Clymenites. This was explained by Bronn, the editor, in a footnote, as being a desirable alteration in order to prevent confusion with the living annelid genus Clymene. Schindewolf (1971) however, suggested that this modification was simply to bring the ending into conformity with other known ammonoid genera: Ceratites, Goniatites, Ammonites.

In 1837 Pusch described clymeniids and goniatites from the Holy Cross Mountains, Poland. The next Famennian ammonoids to be discovered were found by Otto at Ebersdorf in Grafschaft

Glatz, Lower Silesia (now Dzikowiec, Dolny Slàşk, Poland), and were described by von Buch (1838). In the same year Ansted (1838) described clymeniids (for which he proposed the generic name Endosiphonites) and goniatites from near Launceston, Cornwall. Ammonoids were also found in Devon by Sedgwick and Murchison (Sowerby 1842) and by Phillips (1841).

Münster, in semi-retirement from his position in the Prussian Civil Service, started to describe, with the help of other scientists (eg. Meyer, Unger), his large collection of fossils in a series of articles published in a periodical he established, entitled Beiträge zur Petrefaktenkunde. Seven volumes were published before his death in 1844 and several (Vol.1, 1839; Vol.3, 1840; Vol.5, 1842) contained descriptions of further newly discovered ammonoid species from the Fichtelgebirge.

At about the same time Upper Devonian ammonoids of Frasnian age were discovered in the southern Timan Domanik Schiefer by Keyserling (1844), and from Westphalia and the Rhineland by Beyrich (1837) and Steininger (1834). It was only later, with the extensive works of the Sandberger brothers, Guido and Fridolin, that Famennian ammonoids were described from localities in Westphalia (Nehden, Enkeberg and Warstein) now regarded as classic, and Hesse (Sessacker and Kirschofen), (Sandberger and Sandberger 1850-56; G. Sandberger 1853, 1857). Elsewhere in Germany Richter described goniatites and clymeniids from Bohlen near Saalfeld in Thuringia (Richter 1848; Richter and Unger 1856) including in the former work a new species, Goniatites sphaeroides, later recognised by Schindewolf (1924, p. 107) as Wocklumeria, a clymeniid, and characteristic of the uppermost part of the Famennian.

Further discoveries of Famennian ammonoids were made in south-west England (M'Coy 1852) and the Ardennes (Hébert 1855, p. 1179; Dehée (1929) was unable to locate these specimens and thus verify the record). C. W. Gümbel (1862, 1863) was responsible for a conservative revision of Münster's works, based on a restudy of his collections in Munich. His consideration of the clymeniids contains the first serious attempt to sub-divide the genus Clymenia.

During the next thirty years there was little or no new systematic description of Famennian ammonoids, but there were many reports widening the area from which they were known. Tietze (1871) revised the faunas of Ebersdorf and Kayser began what was to be a series of reports (1870, 1871, 1873, 1878) on the Devonian rocks of the Rheinische Schiefergebirge, which included some descriptions of ammonoids. In 1873 Kayser introduced a sub-division of the Upper Devonian, in which the lower Cypridina Stufe (lacking clymeniids) was separated from an upper Clymenia Stufe (with clymeniids), which represented the first attempt to produce an ammonoid biozonation of the Famennian. Kayser (1873) described faunas from Nehden and Enkeberg, two important localities near Brilon, Westphalia. Many thousands of beautifully preserved haematitic goniatites have come from Nehden, first reported by the Sandberger brothers (1850-56) using material collected by von Dechen. Enkeberg, with an equally rich ammonoid fauna, was to be the source of much material used by Frech (1902) and Wedekind (1908, 1913b, 1914, 1917) to initiate modern studies of Famennian ammonoids in Germany. Branco (1880) included Famennian ammonoids in his study of the juvenile stages of cephalopods. Notably he recognised the ventral position of the siphuncle in the first chambers of clymeniids.

Late 19th Century Records

North America

Famennian ammonoids were still unknown in the Americas when Hyatt (1884) fundamentally revised the generic classification of Palaeozoic ammonoids. He formalised Gümbel's division of Clymenia into "Untergattungen" by regularising the Latin endings of their names, creating three families: Cyrtoclymenidae, Cymaclymenidae and Gonioclymenidae, and recognising six genera: Cyrtoclymenia, Oxyclymenia, Platyclymenia, Cymaclymenia, Sellaclymenia and Gonioclymenia. Three more, Cryptoclymenia, Cycloclymenia and Discoclymenia, were later found to be goniatites. Hyatt (1884) divided the Famennian goniatites into distinct genera: Tornoceras, Maeneceras, Sporadoceras, Brancoceras (later renamed Imitoceras, Schindewolf 1921, 1923a), and Dimeroceras. He later added one more, Paratornoceras, (Hyatt 1900).

In 1892 Clarke reported the discovery of a clymeniid, Clymenia (Cyrtoclymenia) neopolitana from the "Naples Shale" (Cashaqua Shale) of Shurtleff's Gully, New York State. Hyatt (1900, p. 548) placed the species in a new genus, Acanthoclymenia. This anomalous early Frasnian record was confirmed by Miller (1938, p. 192) and accepted by Schindewolf (1955, p. 422) who erected the monospecific family Acanthoclymenidae to accommodate it. House (1961) restudied Clarke's type material and recognised that A. neopolitana was in fact a Manticoceras, and thus there was no record of clymeniids from the Frasnian. Clausen (1971, p. 196) established a sub-genus Manticoceras (Maternoceras), with type species Ammonites calculiforme Beyrich 1837, for his Manticoceras (Mant.) Group III (1969, p. 16), in which he had included Acanthoclymenia neopolitana (Clarke). Therefore, Maternoceras can be recognised as a junior subjective synonym of Acanthoclymenia Hyatt.

Russia

Karpinskiy first reported details of Famennian ammonoids from the western Urals, including clymeniids (1884), and the distinctive genus Prolobites (1885, p. 336). Chernyshev (1887b) described similar faunas from the southern Urals (Ishikay, Sikashty and Terekly Rivers), noting the presence of a lower Famennian Cheiloceras fauna, which was also found in the northern Urals (Yaura River) by Krotov (1888). In 1891 Loewinson-Lessing (1892) observed upper Famennian ammonoids from the eastern Urals (Guberlinski Mountains), and in 1903 Tokarenko described ammonoids from the Famennian of the Verkhneural'sk region in the southern Urals. First reports from the Mugodzhar were made by Makhimson in 1911. A more detailed review of the early development of Famennian ammonoid studies in Russia was written by Bogoslovskiy (1969).

Europe (excluding Germany)

During the last quarter of the last century there were numerous reports of newly discovered Famennian ammonoid faunas, most notably by Frech from the Carnic Alps (1887b), Graz (1887) and the Montagne Noire (1887a) (though reports of goniatites from Hérault date from much earlier than this). Barrois (1898) reported ammonoids from Rostellec on the Rade de Brest, Brittany, from the Pyrénées (1898) and from Asturia (1882). Pruvost (1912) gave reports from Southern Portugal and Lovisato (1894) from Sardinia.

20th Century Studies

Northern Europe

It is better to consider the study of Famennian ammonoids after this time on a regional basis. Germany is considered firstly because it is here that the majority of 20th century studies have been made.

Eastern Rheinische Schiefergebirge

Modern studies can be said to have as their starting point the later publications of Frech (1897, 1902). A revision of the *Lethaia Palaeozoica* (Frech 1897) included a global consideration of Devonian stratigraphy and details of fossil occurrences, including ammonoids. Two new genera, *Cheiloceras* and *Pseudoclymenia*, were introduced. Frech summarised much of his life's work on the taxonomy and evolution of Devonian ammonoids in a large monograph *Ueber devonische Ammoneen* (1902) in which many specimens were illustrated. The species concepts he established were followed by many subsequent German palaeontologists. In 1904 he published a short paper on goniatites from Ebersdorf with triangular coiling, which were later (Schindewolf 1937a) recognised to be clymeniids. His final contribution (Frech 1913) was a catalogue listing all known Devonian ammonoids, and a chart which proposed an ammonoid zonal scheme derived from the early work of Wedekind.

Wedekind published a series of papers before and during the First World War dealing with Frasnian and Famennian ammonoids of the Rheinische Schiefergebirge. His first paper (1908) was a description of faunas collected from a trench, dug through the Famennian at Enkeberg in the eastern Sauerland. This was the first bed-by-bed study of Famennian ammonoids. A number of genera were introduced (Centroceras, Protactoclymenia, Varioclymenia, Orthoclymenia, Genuclymenia, Rectoclymenia, Praeglyphioceras); only the last three have survived the ravages of the taxonomic revisers and strict interpretors of the Code. A similar fate may also await the many species he established at the same time.

Wedekind then turned his attention to the Balve area of the western Sauerland where upper Famennian faunas are more easily collected. In 1910 he recognised homeomorphy of shell and suture line between the tornoceratid, Posttornoceras (gen. nov.) and the cheiloceratid, Sporadoceras. Later (1913a) he studied what he thought was an evolutionary series between Parodiceras, Prolobites and Postprolobites (gen. nov.). His monographs on Frasnian goniatites (1913b), clymeniids (1914) of the Rheinische Schiefergebirge, and Devonian goniatites (1917) were more substantial works in which some taxonomic revisions were made. These included the introduction of new clymeniid genera Balvites, Laevigites and Kalloclymenia, Wocklumeria which he regarded as a goniatite, and a sub-generic division of Cheiloceras into Cheiloceras, Staffites and Torleyoceras, based on the nature of the lobes of the internal suture. Over the course of these articles Wedekind had been developing his zonal scheme for the Famennian and a final version of this was published in 1926.

O. H. Schindewolf was a student of Wedekind when at Marburg. Between 1916 and 1972 he published much dealing with cephalopods in general, and Famennian ammonoids in particular, achieving a pre-eminent status amongst German speaking palaeontologists. Most of his early published work dealt with faunas from Thuringia and is considered in that section below.

Hermann Schmidt (1921) described a continuous profile through the Upper Devonian at the Provinzial Steinbruch, Drewer in the Warstein Anticline of the eastern Sauerland. He proposed an evolutionary model of progressively deepening lobes in the Cheiloceratidae and Sporadoceras. Two genera were introduced, Eucheiloceras and Dyscheiloceras. Later he studied faunas from around the Devonian-Carboniferous boundary near Balve, recognising the superposition of the Gattendorfia Stufe over the Wocklumeria Stufe (contra Schindewolf 1920, 1921, 1923a), and also collecting a fauna of imitoceratids from the Stockum Limestone. Lenticlymenia was introduced. Schmidt attempted to use the terms Nehden, Hemberg, Dasberg as replacements for Wedekind's Cheiloceras Stufe, Postprolobites and Platyclymenia Stufe, and Laevigata and Wocklumeria Stufe.

The 1920's and 1930's was a period of intensive study of Upper Devonian and Carboniferous stratigraphy of the Sauerland, resulting in the publication of a series of 1:25 000 geological maps, including Balve (Paeckelmann 1938). During this time many trenched sections were cut through the Famennian: at Enkeberg, by Lange 1922, 1923 and Paeckelmann 1925; at Beuel, by Lange 1922, Paeckelmann 1931, Schindewolf 1934; the Hönnetal railway-cutting, by Schindewolf 1928-1934; at Dasberg, by Paeckelmann and Schindewolf 1930; and at Ballberg (Hövel), by Schindewolf 1931. Lange published a revision of Wedekind's Enkeberg profile in 1929, together with a description of material from the annulata Zone at Beuel, from Dasberg and Borke-Wehr and introduced two new genera, Stenoclymenia and Balvia. Between 1925 and 1945 O. H. Schindewolf worked for the Preussische Geologische Landesanstalt (later known as the Reichsamt Reichstelle für Bodenforschung), during which time he published only two papers dealing with Famennian ammonoids of Germany. One was, however, a brilliant detailed study dealing especially with peculiar triangular coiled clymeniids of the Wocklumeria Stufe from the Oberrödinghausen railway-cutting in the Hönnetal (Schindewolf 1937a). The following genera were established: Progonioclymenia, Soliclymenia, Pachyclymenia, Epiwocklumeria, Postglatziella, Kamptoclymenia, Triaclymenia and Piriclymenia.

The other paper, published in the same year (Schindewolf 1937b), dealt with more rare ammonoids. Archoceras and Clymenoceras were two new genera established in an attempt to describe the evolution of the family Phenacoceratidae Frech.

Then followed a long period of relative quiescence in the study of Famennian ammonoid faunas in this classic area. With the exception of a short contribution by Schmidt (1952) on the Prolobitidae we have had to wait until recently when there have been several short papers by Korn (Korn 1979, Clausen et al. 1979, Korn 1981a,b). Korn (1979) described ventral spines from Kosmoclymenia Schindewolf, a major morphological character which had escaped description by palaeontologists for nearly 150 years. He also (in Clausen et al. 1979) described clymeniids collected during the remapping of Blatt Hirschberg by the Nordrhein Westfalen Geologisches Landesamt. In 1981 he published a taxonomic revision of Cymaclymenia (1981a), and gave details of a Stockum Limestone age imitoceratid fauna (1981b).

This dearth of activity can be partly attributed to the turmoils of the Second World War, partly to the belief that the faunas had been exhaustively monographed and partly to palaeontologists turning their attentions to conodonts, fossils more suited to a biostratigraphical role in mapping. The purpose of this study has been to examine the first premise, and also to attempt to correlate the established ammonoid zonal schemes of Wedekind and others, with the newly established conodont scheme which has figured so much in recent stratigraphic studies.

The only descriptions of Famennian ammonoids from the south eastern (basinal) Rheinische Schiefergebirge were made by Drevermann (1901) and Matern (1931). Both looked at goniatites and clymeniids from trenches and ironstone quarries in the Dill Syncline; Drevermann from Langenaubach and Matern from Sessacker. Schindewolf (1934) incorporated material from trenches at Ense, near Bad Wildungen in the Kellerwald, in his revision of the genus Platyclymenia Hyatt. Other references to localities in the Rheinische Schiefergebirge can be found in Schindewolf (1921).

Harz

East of the Rheinische Schiefergebirge in the Harz Mountains Born (1912a), a near contemporary of Wedekind at Göttingen, described goniatites and clymeniids from Aeketal, and the same sections were restudied by Fuhrmann (1954). These sections, and trenches excavated through the same sequence at Sessacker that Matern had studied, were used by Ziegler (1962) for the lower Famennian part of his conodont studies.

Oberfranken, Ostthüringen, Sächisches Vogtland

The area of Ostthüringen, Sächische Vogtland and Oberfranken, now in north eastern Bavaria (BRD) and south western East Germany (DDR), has received more attention from Famennian ammonoid palaeontologists than any other in the world. It was from the Fichtelgebirge (Oberfranken) that Famennian ammonoids were first reported by Count Münster in 1831, and later in 1848 Richter described similar faunas from Bohlen near Saalfeld (Ostthüringen).

O. H. Schindewolf began his ammonoid studies with a description of the Famennian of the Oberfranken, principally at a quarry at Kirch-Gattendorf near Hof, under the direction of Wedekind in Marburg. This resulted in a series of articles describing the faunas and the stratigraphic succession (Schindewolf 1916, 1920, 1923a,b, 1924, 1926). Initially he placed the Gattendorfia Stufe below the Wocklumeria Stufe. At Gattendorf Wocklumeria Stufe faunas, or at least Wocklumeria itself, are absent. From Bed 20 Schindewolf (1923a) recorded clymeniids, and above in Bed 21, he recorded Gattendorfia. The absent Wocklumeria Stufe was thought to belong next above. Schindewolf introduced the following genera: 1920: Costaclymenia, Schizoclymenia, Sphenoclymenia; 1921: Imitoceras, Biloclymenia; 1923a: Wedekindoceras, Hexaclymenia, Falciclymenia, Protoxyclymenia, Otoclymenia; 1923b: Miroclymenia; 1926: Parawocklumeria, Trochoclymenia.

Born (1912b) reported a presumed occurrence of Cheiloceras and clymeniids from Bohlen. The material described as Cheiloceras was later shown to be Prionoceras. Schmidt (1923) revised the identifications of Richter's (1848) Famennian ammonoids from Bohlen. Schindewolf then turned his attention to the Saalfeld region, publishing papers in 1924, 1928 and 1952. His further contributions to the study of Famennian ammonoids lay in papers dealing with the phylogeny and systematics of clymeniids (1949a,b, 1955), producing the Treatise section on clymeniids (1957) and in a posthumously published paper (1972) he summarised many of his ideas. Two more genera were established, Kosmoclymenia (1949a) and Sulcoclymenia (1972).

In 1954 Pfeiffer described the geology of the Bohlen area, and collected Wocklumeria from its type area for the first time since Richter, over 100 years before. Lately Bartzsch and

Weyer (1980) have described ostracods, conodonts and again *Wocklumeria* from the same sequences. Müller (1956) described Upper Devonian faunas, including ammonoids, from near Schleiz (Ostthüringen). Brügge (1973) described collections of conodonts and ammonoids from Müller's Alte Heerstrasse section, and provided evidence for the correlation of ammonoid and conodont zones. Weyer has recently (1981) described *Glatziella* and *Parawocklumeria* from Schleiz, and revised the classification of the Gonioclymeniina.

Less information is avaliable from Vogtland. Schlosser (1927) recognised all six Upper Devonian Stufen in the Plauen region and Gallwitz' (1938) statistical study of Frasnian *Archoceras* included material from here. Freyer (1957) described faunas from the same and other sections in the Plauen area.

Silesia

Leopold von Buch (1832, 1838) and Beyrich both collected from Ebersdorf in Nieder Schlesien (now Dzikowiec, Dolny Śląsk, Poland) and Tietze (1871) described the fauna at length. Since then the only published fossil descriptions have been by Renz (1913a,b, 1925), who established (1913b) the clymeniid genus *Glatziella*, with a number of species. Schindewolf (1921, p. 179; 1937a, p. 20) listed faunas ranging from the *annulata* Zone to the *Wocklumeria* Stufe and more recently Lewowicki (1959) has described Famennian ammonoids and Weyer (1965) has described *Gattendorfia* Stufe goniatites, which Frech (1902) had earlier considered as Devonian.

Czechoslovakia

Famennian clymeniids and goniatites were discovered near Brünn (now Brno, Moravia, ČSSR) by Rzehak (1881) which he later described in detail (1910). The range of genera described demonstrate the presence of a sequence from the *Cheiloceras* to *Clymenia* Stufen. Koliha (1929) reported *Cheiloceras* from the Ještěd Mountains. Kettner (1933) and Patteisky (1929) reported a poorly preserved *Kalloclymenia* sp. from Moravia. Chlupáč (1966) described *Clymenia*, *Protoxyclymenia* and *Sporadoceras* also from Moravia, but was unable to recollect from the doIV levels described by Rzehak. Chlupáč (Chlupáč and Zikmundová 1976) reported *Cheiloceras* and *Clymenia* from a bore hole near Hradec Králové, in eastern Bohemia.

Elsewhere in north western Europe Famennian ammonoids are known from the shelf facies (= Rhenish) of the Old Red Sandstone continent from Velbert, Bergisches land and Aachen in Germany, and further west in Belgium and north eastern France. Ammonoids are also known from Brittany, and, appropriately enough, from the Devonian "type-area" of Devon and Cornwall in south western England.

Dinant Basin and the Eifel Mountains

Early records from the Ardennes have already been discussed. In the Dinant Basin Delépine (1929) reported *Cymaclymenia camerata* Schindewolf from the Étroeungt of Sémeries, northern France, Dehée (1929) recorded clymeniids from Avesnelles, northern France, and Sartenaer (1957) reported the discovery of the *Cheiloceras curvispina* zone from near Limburg, eastern Belgium. House (1973) reported *Cheiloceras* from near the Frasnian-Famennian boundary at Senzeilles, the type section. *Cheiloceras* is also known from further east in Aachen Anticline (Holzapfel 1910, Wulff 1923, Kasig *et al*. 1979) and Wolfgang Schmidt (1956) recorded

Kosmoclymenia undulata (Münster).

The only other reported occurrence of Famennian ammonoids west of the Rhine is at Büdesheim (Clausen 1968) a locality which has long been famous for its Frasnian faunas (Steininger 1834; Sandberger and Sandberger 1851-6). East of the Rhine, in the Bergisch Gladbach-Paffrath Syncline, Jux and Krath (1974) described what must be the most delicately preserved pyritised Famennian goniatites. Cheiloceratids and tornoceratids were recovered from a building trench through the Knoppenbiessen Beds near Bensberg.

The only other important non-Cephalopodenkalk locality for Famennian ammonoids in northern Germany is the Herzkamp Syncline. Most common are IIα level faunas of cheiloceratids and tornoceratids, described by Grüneberg (1925). Higher levels are also present and clymeniids were reported by Paeckelmann (1913, 1921, 1922) and Paul (1939).

Armorica

The only recent studies have been by Babin (Babin 1966, Babin *et al*. 1976) who has described faunas consisting of *Cheiloceras*, *Tornoceras* and *Lobotornoceras* from near the Frasnian-Famennian boundary of the Rade de Brest. Further east Péneau (1929) described upper Famennian clymeniids, including *Wocklumeria*, from St. Julien-de-Vouvantes (Loire Atlantique) near Angers, and Babin and Paris (1973) reported *Tornoceras* and *Aulatornoceras* from near Rennes.

South West England

House and Selwood have recently contributed much to our knowledge of Famennian ammonoids from south west England, which had lain relatively unstudied since the 1850's. House (1956) reported Cheiloceras from Padstow, north Cornwall, and later, House (1960), Platyclymenia, Kosmoclymenia and Imitoceras from near Tavistock, Devon.

The discovery of Wocklumeria from Launceston, east Cornwall (House and Selwood 1957) was most significant. This, when taken together with the collections of Ansted and Phillips, proved a sequence in that area from the Platyclymenia to Wocklumeria Stufen. The faunas were described by Selwood (1960) in greater detail, and two genera were introduced: Kenseyoceras and Mayneoceras. A similar suite of ammonoid faunas from Chudleigh, south Devon, was also recorded by House (Butcher and House 1961, House 1963, House and Butcher 1975).

Poland

Tracing descriptions of Famennian ammonoid faunas from Poland is complicated somewhat by the politics of the twentieth century. Traditionally this work had been carried out by Germans and Russians in the employment of the Russian Imperial Survey. Faunas from Ebersdorf (Dzikowiec) were discussed in the German/Silesia section.

Gürich (1896, 1909) described Famennian ammonoids from the Holy Cross Mountains near Kielce, and subsequent authors have worked in the same area. Dybcynski (1913) published an outline report of the scope of faunas present at Kielce, ranging from the base of the Famennian to the Clymenia Stufe. The report was introduced as preliminary to a monograph, but this was never published. Two goniatite genera were introduced: Protornoceras and Polonoceras.

Czarnocki (1909, 1928, 1938) published a number of articles on the Devonian and Carboniferous palaeontology and stratigraphy of the Kielce region. That he also planned a monographic description of Famennian ammonoid faunas is alluded to in a catalogue of fossils (Rühle 1972) in which many museum determinations are attributed to Czarnocki. This includes many new genera and species, which are all nomina nuda. The list of species present suggests that the Wocklumeria Stufe is fully developed at Kielce.

The work of Sobolev requires more than a little comment, (but see Chapter 4). Between 1911 and 1928 he published a series of articles on the Upper Devonian of the Holy Cross Mountains, mostly in Russian, in unaccessible Polish/Russian journals. His major contribution was Nabroski po filogenii goniatitov (1914a), an outline of which was published in German (1914b) and is therefore more readily studied. Essentially Sobolev believed in a polyphylectic origin of the clymeniids from goniatites, which he substantiated by a series of "phylogenetic" lineages now recognised merely as homeomorphic groupings.

Makowski (1962) used specimens of Cheiloceras subpartitum (Münster) and Paratorleyoceras globosum (Münster) as examples of the occurrence of sexual dimorphism in early goniatites. Kalis (1969) reported Kosmoclymenia and Cheiloceras from boreholes at Opole Lubelskie and Niedrzwica, in the western Lublin basin. House (1970) used material from the lower Famennian of the Kielce region, described earlier by Dybcynski (1913) and Sobolev (1914a,b), to illustrate his arguments outlining the origin of the clymeniids. He introduced the new genus Tornia.

Southern Europe

Carnic Alps

Little has been added to our knowledge of Famennian ammonoids of the Carnic Alps since Frech's (1902) study. D'Angelis Ossat

(1897) illustrated what appears to be a species of _Balvia_ from Pal Grande in the Carnic Alps and Gortani (1907) described in detail a fauna from Casera Promosia, nearby. Recently House and Price (1980) have revised old reports of ammonoids, preliminary to a restudy of the rich faunas from this area.

Montagne Noire

Böhm (1935) is the only person to have published on the Famennian ammonoids of the Montagne Noire this century.

Spain

Our understanding of late Devonian ammonoids from the Iberian peninsula was poor until Kullmann made a study in the Cantabrian Mountains of Spain twenty years ago, (Schindewolf and Kullmann 1959, Kullmann 1960). A large number of Devonian ammonoids were described, from the Emsian upwards, including a complete sequence through the Famennian.

Greece

Recently Roth (1964) reported the occurrence of _Cheiloceras_ from the island of Chios in the eastern Aegean.

North Africa

Famennian ammonoids were first discovered in the central Sahara in 1903 (Haug 1903). By 1933 (Menchikoff 1933) sufficient was known of the ammonoids of the Saoura valley and the Ougarta Mountains for all the German ammonoid Stufen to be recognised in North Africa. Later Clariond, Termier and Roch (_fide_ Petter 1959) demonstrated the presence of similar faunas further west in

Morocco. The first detailed descriptions of the faunas were prepared by the Termiers (Termier and Termier 1948, 1950) and much of this material was redescribed in detail by Petter (1959, 1960). Buggisch and Clausen (1972) described sequences across the Frasnian-Famennian boundary in Morocco.

USSR

Perna (1914) described the Famennian faunas of the Verchneuralsk' region (Chelyabinsk Oblast'), east of the Urals, enlarging on the contributions of Karpinskiy (1884) and Tokarenko (1903). The faunas indicate the presence of a sequence ranging from the *Cheiloceras* to *Platyclymenia* Stufen. In a review of Perna's exemplary study Schindewolf (1922) introduced a new genus, *Pernoceras*. Nalivkina (1936a) described *Cheiloceras* and *Cyrtoclymenia* from the western coast of Novaya Zemlya, and from the southern Urals (1936b). Later (1953) she described a fauna of almost exclusively *Platyclymenia* Stufe age from the Mugozhar (Novorossik Region, Aktubinsk Oblast') which had been discussed briefly by Kind (1944). Kolotukhina (1938) described a *Platyclymenia* Stufe fauna from Kazachstan (Kairakty, Karaganda Oblast').

Over the last 25 years B. I. Bogoslovskiy has been responsible for a series of major papers on the Devonian ammonoids of Russia, mostly from the Timan and the Urals. Much of his work describes specimens collected by various expeditions and survey programmes. Famennian faunas have been described principally from the southern Urals (Bashkirskaya ASSR) and Kazakhstan (Mugozhar Mountains = Aktubinsk Oblast', and Karaganda Oblast'), but also from the northern Urals. The following genera were introduced: 1955; *Kiaclymenia* (River Kiya, Aktubinskaya Oblast'); 1957; *Sedgwickoceras*, *Paratorleyoceras*, *Polonites*, *Paradimeroceras* (S. Urals);

1962; Spinoclymenia (R. Kiya, Akt. Obl.); 1965; Carinoclymenia (Kara-Zhar, Sukhinorskiye, Akt. Obl.); 1975; Acriclymenia (Kara-Zhar, Akt. Obl.), Pinacoclymenia (R. Kiya, Akt. Obl.); 1977; Uraloclymenia (R. Man'ya, N. Urals, R. Kiya, S. Urals; R. Sherubay-Nura, Karaganda Obl.); 1979a; Cteroclymenia (Kara-Zhar, Akt. Obl.); 1979b; Aktuboclymenia (Kara-Zhar, Akt. Obl.), Kazakhoclymenia (R. Sherubay-Nura, Kara. Obl.), Ornatoclymenia (R. Kiya, Akt. Obl.), Laganoclymenia (R. Kiya, Akt. Obl.); 1981; Mesoclymenia (R. Sherubay-Nura, Kara Obl.), and Riphaeoclymenia (R. Kiya, Akt. Obl.). In a work dealing with mainly Carboniferous ammonoids Librovich (1947, 1957) introduced Acutimitoceras, and Synwocklumeria, described from the River Ryazyak (Bash. ASSR), and later reported by Bogoslovskiy (1981) from the River Marukhye in the northern Caucasus.

An atlas of key fossils found in the USSR (Nalivkina 1947) illustrated many Famennian ammonoids. In 1962 the Osnovi Palaeontologii volume on cephalopods covered Devonian ammonoids in depth (Bogoslovskiy 1962) and recently Bogoslovskiy has contributed to knowledge of the nature of the siphuncle in the early stages of clymeniids (1976) and has discussed the phylogeny of the Clymeniina (1979b), and Gonioclymeniina (1981).

South Central Asia

Iran

Walliser (1966) described goniatites and clymeniids of the Platyclymenia Stufe from the Shotari Range of north eastern Iran, and introduced the subgenus Sporadoceras (Iranoceras).

Pakistan

Platyclymenia has been reported from near the Khyber Pass in Pakistan (Talent and Mawson 1979).

China

There is only one early record of Famennian ammonoids from China; Mansuy (1912) identified Paradoceras globosum (Münster) which may be Paratorleyoceras sp. However, within the last twenty-five years there has been a great increase in our knowledge. Chang (1958) described two new genera, Sinotites and Sunites, from near Taminshang in the Great Khingan. Further aspects of the fauna were subsequently described (Chang 1960), which indicated levels ranging from the Cheiloceras Stufe to the annulata Zone.

The presence of the Clymenia and Wocklumeria Stufen was demonstrated by Sun and Shen (1965) from Kweichow, Kwangsi and north eastern Yunnan with a rich suite of goniatites and clymeniids. Two genera, Sinoglatziella and Asioclymenia, were introduced. Ammonoid faunas from the Wocklumeria Stufe have also been discovered in Kansu and Sinkiang by Ruan and He (1978), and recently Ruan (1981) described in detail the ammonoid fauna of the Daihua Formation of Kwangsi and Kweichow.

Australia

The presence of Famennian ammonoids in Australia was first recognised by Foord (1890) who studied specimens sent to him from the Kimberley District of the Canning Basin, Western Australia. These were first described in detail by Delépine (1935). Further collecting by Teichert since 1939 (Teichert 1941, 1943) and later by a number of institutions has resulted in the recognition of goniatites and clymeniids ranging in age from the *Cheiloceras* to *Clymenia* Stufen. These have been described in detail by Petersen (1975).

Famennian ammonoids from eastern Australia are less well known. Pickett (1960) reported *Cymaclymenia* and *Platyclymenia* from north eastern New South Wales. From the same area Jenkins (1966) subsequently described *Cheiloceras acutum* Münster, indicative of the lower *Cheiloceras* Stufe. However, the identification of the poorly preserved specimens is open to question, and they may be *Tornoceras*. Reports from higher levels (Jenkins 1968) of *Genuclymenia*, *Platyclymenia* and *Sporadoceras*, although based on poorly preserved material, are more convincing.

North America

Few Famennian ammonoids are known from North America, but older Devonian faunas are comparatively more widespread.

Western Canada

The only records of Famennian ammonoids are of a *Cheiloceras* Stufe fauna (*Cheiloceras*, *Sporadoceras* and *Dimeroceras*) from the North West Territories, and a possible *Platyclymenia* from Fisher Range, Alberta (House and Pedder 1963).

Eastern North America

The few known records are from a belt of Devonian rocks cropping out on and near the southern shores of Lake Erie. House (1962, 1968) reported *Cheiloceras*, *Aulatornoceras* and *Maeneceras*. There is an earlier record by Miller and Flower (1936) of *Sporadoceras* from Pennsylvania. These are certainly indicative of the *Cheiloceras* Stufe, and possibly of the lower part of the *Platy-*

clymenia Stufe. Further west in Ohio (House 1978) recorded Cyrtoclymenia, Cymaclymenia and Platyclymenia. Earlier (1962) in Iowa, he had recorded Cyrtoclymenia and Cymaclymenia, and Manger (1973) recognised Falciclymenia.

Montana and New Mexico

The Three Forks Shale fauna of Montana was first described by Raymond (1907, 1909, 1911) and was restudied by Schindewolf (1934). He considered it to be from the Platyclymenia Stufe and introduced a new genus, Raymondiceras. House (1962) recognised Rectoclymenia. Miller and Collinson (1951) reported Falciclymenia from the Percha Shale of New Mexico.

Miscellaneous Subjects

Walliser (1970) and House (1971) have both described wrinkle-layer structures in Famennian ammonoids. In a posthumously published article Schindewolf (1972) discussed many aspects of his life's work, including clymeniids. House has written several papers (1964, 1971, 1972, 1973) dealing with the distribution of Devonian ammonoids, and these include accounts of Famennian ammonoids, particularly Cheiloceras and Platyclymenia (1971). Drushchits, Bogoslovskaya and Doguzhaeva (1976) described the evolution of ammonoid septal necks, including details of the Clymeniida.

Chapter 3

The ammonoid zonation of the Famennian

Introduction

This chapter is divided into four parts. Firstly the subdivisions of the Famennian in Belgium are examined, considering especially reports of ammonoids. Then follows a detailed discussion of the ammonoid zonation of time-equivalent rocks in the Rheinische Schiefergebirge, for which no single name exists, save "mittleres und oberes Oberdevon". Two charts summarise the evolution of the Stufen and zonal terminologies (Textfigs. 3,1 and 3.2a-d, respectively). Reports of ammonoid biostratigraphy are critically examined, especially the unrivalled account of Wedekind (1908), and those of Schindewolf (1916 *et seq.*), Schmidt (1921, 1924), Lange (1929), Matern (1931), and Wedekind (1913a,b, 1914). For the two intervals *curvispina*-*annulata* Zone (Wedekind 1908) and the *Wocklumeria* Stufe (Schindewolf 1937a) little that is significant in terms of ammonoid specific ranges, has been added to date. Precise evidence is newly presented here for the intervening *annulata* Zone and *Clymenia* Stufe.

In a brief section the use of ammonoid zonal names within the Famennian is rationalised, each zone being defined. Finally, using information accumulated for this thesis and from the literature, a series of 23 faunal levels based on specific ranges are newly recognised. These are related to the zones.

The Famennian

The Famennian, used as a name for the uppermost Stage of the Devonian, was established as a name for a series of shelf clastics with subordinate carbonates, almost lacking in ammonoids, in the Dinant Basin of southern Belgium (Gosselet 1860, Mourlon 1875, *fide* Lecompte 1956). Brachiopods (Gosselet 1877), and more recently conodonts (Bouckaert, Ziegler and Thorez 1965) and spores

(Bouckaert _et al_. 1968), have been used as the principal means of biostratigraphic correlation within it.

Over the same period of time German authors (see below) have devised an ammonoid zonal scheme in condensed ammonoid-rich carbonates in the Rheinische Schiefergebirge. Correlation between the two areas has largely been based on lithological grounds, in the Aachen and Velbert areas, where the two facies overlap to some degree. Ziegler's (1962) work on the conodont faunas of the Rheinische Schiefergebirge has enabled the Famennian of Belgium to be more accurately correlated with the German sequences.

Famennian of Belgium

A review of the evolution of the terminology of the subdivisions of the Famennian can be found in the _Lexique Stratigraphique_ (Lecompte 1956). During the last twenty-five years there have been serious attempts to provide a biostratigraphy of the Famennian, so that it can justifiably be used as a stage name outside its historical type-area with some degree of reliable correlation.

Sartenaer (1957 _et seq_., see references in Sartenaer 1970) has provided a series of articles refining a rhynchonellid zonation of the lower Famennian. He also published a detailed description of the now destroyed Frasnian/Famennian boundary type-section at Senzeilles, and showed that the sequence through the Assises de Senzeilles was not complete.

Bouckaert _et al_. (1965) proved the conodont zones which Ziegler (1962) had recognised in the Rheinische Schiefergebirge (see Chapter 6 for a discussion of the Famennian conodont zones) to be present in Belgium, thus permitting a more precise correlation between the Famennian of Belgium and Germany.

Bouckaert _et al_. (1965) also helped to clarify the limits to the Famennian. Gosselet (1877, p. 306) had placed the Frasnian/Famennian boundary at Km 101.026 in the railway-cutting at Senzeilles at the base of a 6m thick unit, where "Cyrthia murchisoniana" entered the record. Bouckaert et al. (1965) obtained a Middle triangularis Zone fauna from a limestone 6m above this level. Later Bouckaert, Mouravieff, Thorez, Streel and Ziegler (1972) attempted to improve the documentation of the Frasnian/Famennian boundary in Belgium. They pointed out that the conodont record at Senzeilles was incomplete, the Lower triangularis and Upper gigas Zones being unrecognised. By studying another sequence at Hony, they pointed to a major change in the conodont faunas occurring between the Upper gigas and Lower triangularis Zones, which, by means of a simultaneous significant change in the composition of the arcritarch fauna, they correlated with a level some two metres above Gosselet's Frasnian/Famennian boundary at Senzeilles. On this basis they proposed that the Frasnian/Famennian boundary be redrawn at Hony at the base of Bed 48b, which was coincident with the base of the Lower triangularis Zone.

The Tournasian is the stage overlying the Famennian, and the boundary between them was equated with the Devonian/Carboniferous boundary. However, Bouckaert et al. (1965) reported a costatus Zone fauna from levels assigned to the zone Tn1a, the lowest Tournaisian, which, by comparison with the conodont and ammonoid faunas from the Devonian/Carboniferous sequence at Oberrödinghausen, would place it in the uppermost Devonian. The detailed palynological work of Streel (see references in Paproth and Streel 1970) has added to the precision of correlation around these levels. Acceptance of the base of the sulcata Zone (Paproth 1980) as the Devonian/Carboniferous boundary, with the Famennian and Tournaisian stages either side of it, should prompt realignment of the base of the Tournaisian to coincide with the system boundary, and hence define the top of the Famennian.

The Famennian in Belgium was divided on the basis of litho-stratigraphic units (Lecompte 1956). Bouckaert *et al.* (1968) showed that these units were diachronous, and proposed new divisions using biostratigraphic units based on a combination of brachiopod, conodont, spore and foraminiferal zones. The lower/upper Famennian (Fa 1/2) boundary was drawn between the *crepida* and *rhomboidea* Zones, which they said was a major macro- and micro-faunal break, and coincided with a change in lithology in a part of the Dinant Syncline.

There are few reported occurrences of ammonoids in the Famennian of Belgium and France. Dehée (1929, p. 15) stated that such records as there were should be treated with reserve since most of the clymeniids which he had been able to examine in old collections were gastropods. He illustrated (pl. 1, fig. 13) *Cyma*. *evoluta* from Avesnelles, and two further specimens (pl. 1, figs. 11,12) collected from the Carrière du Parcq by Gosselet. Demanet (1958, p. 55) recorded "*Striato*. *euryomphala*" (= *Cyma*. *evoluta* ?) from Landélies, near Namur.

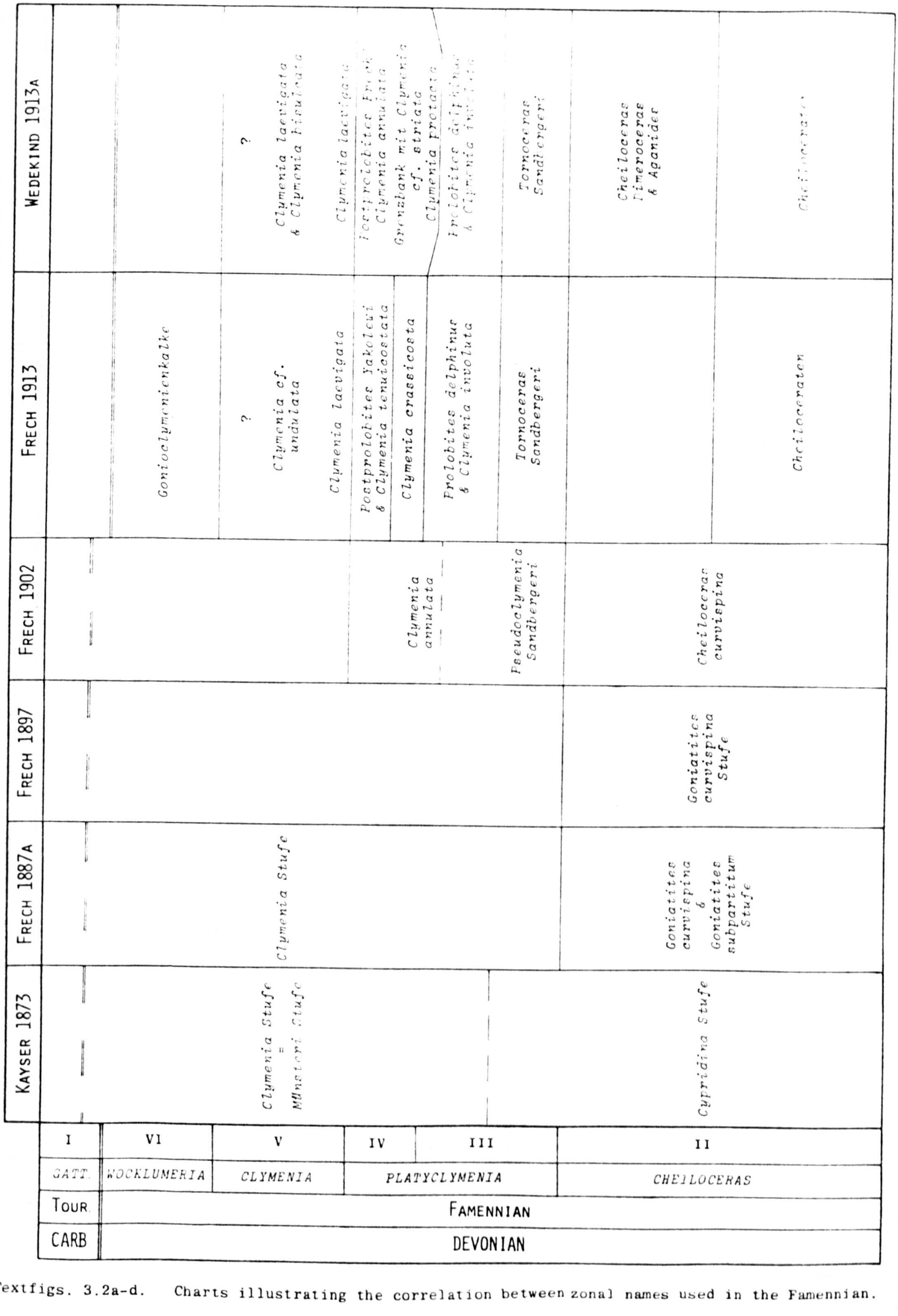
Hébert (1855, p. 1170) recorded *Clymenia undulata* and *Cl*. ? *laevigata* from the Étroeungt. In 1957 Sartenaer (1957a) recognised the *Cheiloceras* Zone near Limbourg, and House (1973) reported a single specimen of *Cheiloceras* (*Torleyoceras*) sp. from a locality on the Aye sheet. Bouckaert *et al.* (1968) show *Cheiloceras*, *Sporadoceras latilobum* and *Cymaclymenia euryomphala* on a range-chart (hors-texte III), but do not state their evidence. Dreesen (1982a,b), in describing distinctive oolite ironstones from the Dinant and Vesdre basins, reported *Cheiloceras circumflexum* and *Ch*. *amblylobum* identified by me. I can report another occurrence near Han-sur-lesse (near Pt. 42 of Sartenaer 1970). A sample collected by Gerd Trost yielded *Cheiloceras circumflexum*

Textfig. 3.1

	Upper Devonian					Carboniferous
	Cheiloceras Stufe II	Platyclymenia Stufe III	IV	Clymenia Stufe V	Wocklumeria Stufe VI	Gattendorfia Stufe I
Kayser 1873	*Cypridina Stufe*	*Munsteri Zone or Clymenia Stufe*				
Frech 1887	*Goniatites curvispina Stufe*	*Clymenia Stufe*				
Frech 1902	*Goniatites curvispina*	*Clymenia*				
Frech 1913	*Cheiloceras* II	*Prolobites* III	*Postprolobites* IV			
Wedekind 1913a	*Cheiloceras*	*Prolobites*	*Postprolobites*			
Wedekind 1913b	*Cheiloceras*	*Prolobites*	*Postprolobites*	*Laevigata* V		
Wedekind 1914	*Cheiloceras*	*Prolobites*	*Postprolobites-Platyclymenia*	*Laevigata-Gonioclymenia*	*Wocklumeria* VI	
Schindewolf 1916	*Cheiloceras*	*Prolobites*	*Postprolobites-Platyclymenia*	*Laevigites*	*Wocklumeria*	
Schindewolf 1921	*Cheiloceras*	*Prolobites*	*Postprolobites-Platyclymenia*	*Laevigites*	*Gattendorfia*	*Wocklumeria* VII
Wedekind 1926	*Cheiloceras*	*Prolobites*	*Platyclymenia*	*Laevigites*	*Wocklumeria*	*Gattendorfia*
Schindewolf 1926				*Laevigites*	*Wocklumeria*	*Gattendorfia*
Lange 1929	*Cheiloceras*	*Platyclymenia* / *Prolobites*	*Prionoceras divisum*	*Orthoclymenia*	*Wocklumeria*	*Gattendorfia*
Matern 1931	Nehden	Hemberg		Dasberg		Hangenberg
Jongmans & Gothan 1937					*Wocklumeria*	*Gattendorfia* I
Miller 1938	*Cheiloceras*	*Prolobites-Platyclymenia* III		*Laevigites-Gonioclymenia* IV	*Wocklumeria-Kalloclymenia* V	
Schindewolf 1952	*Cheiloceras*	*Prolobites-Platyclymenia* III	IV	*Oxyclymenia-Gonioclymenia* V	*Wocklumeria-Kalloclymenia* VI	
Kullmann 1960	*Cheiloceras*	*Prolobites-Platyclymenia*		*Clymenia-Gonioclymenia*	*Wocklumeria-Kalloclymenia*	
House 1962	*Cheiloceras*	*Platyclymenia*		*Clymenia*	*Wocklumeria*	
Erben & Zagora 1967	Nehdenian	Hembergian		Dasbergian		
Ziegler 1979	Nehdenian	Hembergian		Dasbergian	Wocklumerian	

Textfig. 3.1 Chart showing correlation between various names given to Famennian Stufen

Textfig. 3.2a



Textfigs. 3.2a-d. Charts illustrating the correlation between zonal names used in the Famennian.

Textfig. 3.2b

WEDEKIND 1913B	WEDEKIND 1914	SCHINDEWOLF 1916	SCHINDEWOLF 1921	SCHMIDT 1924
			Wocklumeria Denckmanni & Oxyclymenia Wocklumeri	*Postclymenia evoluta*
Gonioclymenienkalke	*Wocklumeria Denckmanni, Kalloclymenia subarmata & Oxyclymenia Wocklumeri*	*Wocklumeria Denckmanni* *Wocklumeria n. sp.*	*Gattendorfia subinvoluta*	*Wocklumeria sphaeroides & Glatziella nucleus*
?	*Laevigites laevigata & Gonioclymenia Tournquisti*	*Laevigites laevigata*	**Laevigites laevigatus Oxyclymenia undulata & Gonioclymenia Kiliani**	*Gonioclymenia speciosa & Cymaclymenia ornata*
	Clymenia aegoceras & Laevigites Hoevelensis	*Laevigites hoevelensis*	*Laevigites Hoevelensis Oxyclymenia subundulata, & Gonioclymenia Torleyi*	*Gonioclymenia Hoevelensis & Platyclymenia acuticostata*
	Postprolobites Frechi & Platyclymenia valida *Platyclymenia annulata var densicosta, Platyclymenia protacta*	*Postprolobites Frechi, Platyclymenia annulata & Platyclymenia protacta*	*Postprolobites Frechi & Platyclymenia spp.* **Platyclymenia protacta** **Platyclymenia annulata var densicosta**	*Platyclymenia annulata*
Prolobites delphinus & Clymenia involuta	*Prolobites delphinus & Clymenia involuta*	*Prolobites delphinus & Clymenia involuta*	*Prolobites delphinus & Cyrtoclymenia involuta*	*Prolobites delphinus*
Tornoceras Sandbergeri	*Pseudoclymenia Sandbergeri*	*Pseudoclymenia Sandbergeri*	*Pseudoclymenia Sandbergeri & Pseudoclymenia Drevermanni*	*Pseudoclymenia Sandbergeri*
Cheiloceras & Dimeroceras		*Cheiloceras enkebergense*	*Cheiloceras enkebergense & Dimeroceras Guembeli*	***Sporadoceras Pompeckji & Cheiloceras***
Cheiloceraten		*Cheiloceras subpartitum*	*Cheiloceras subpartitum*	*Cheiloceras curvispina*

Textfig. 3.2c

	Wedekind 1926	Lange 1929	Schindewolf 1937a	House 1962
		Gattendorfia subinvoluta		
	Wocklumeria Denckmanni, Kalloclymenia subarmata & Oxyclymenia Wocklumeri	*Gonioclymenia wocklumensis*	*Parawocklumeria paradoxa* *Wocklumeria sphaeroides* *Kamptoclymenia endogona* *Kalloclymenia subarmata & Kalloclymenia brevispina*	*Wocklumeria sphaeroides* ***Kalloclymenia subarmata***
	Laevigites laevigatus & Gonioclymenia Tornquisti *Laevigites Hoevelensis & Clymenia aegoceras*	*Gonioclymenia speciosa ?* *Gonioclymenia hoevelensis* *Costaclymenia binodosa*		*Gonioclymenia speciosa* *Gonioclymenia hoevelensis*
	Platyclymenia valida & Postprolobites Frechi ***Platyclymenia annulata var densicosta, Platyclymenia protacta***	*Platyclymenia annulata*		*Platyclymenia annulata*
	Prolobites delphinus & Clymenia involuta	***Rectoclymenia subflexuosa & Cyrtoclymenia involuta***		*Prolobites delphinus*
	Pseudoclymenia Sandbergeri	***Platyclymenia kayseri***		*Pseudoclymenia sandbergeri*
	Cheiloceras enkebergense & Dimeroceraten	***Dimeroceras bennecki***		*Sporadoceras pompeckji*
	Cheiloceras subpartitum	*Cheiloceras (acutum)*		*Cheiloceras curvispina*

House 1978	House 1979	Korn 1981 a	Proposed in this Thesis
Prionoceras sp. *Cymaclymenia euryomphala* *Wocklumeria sphaeroides* *Kalloclymenia subarmata*	*Cymaclymenia* & *Prionoceras* spp. *Parawocklumeria paradoxa* *Wocklumeria sphaeroides* *Kalloclymenia subarmata*	*Cymaclymenia euryomphala* *Parawocklumeria paradoxa* { *Wocklumeria sphaeroides*, *Parawocklumeria distorta* } *Kalloclymenia subarmata* & *Kalloclymenia brevispina*	*sphaeroides* { *prorsur*, *evoluta*, *paradoxa*, *endogona* }
			brevispina
Gonioclymenia speciosa	*Gonioclymenia speciosa*	*Piriclymenia piriformis* *Ornatoclymenia ornata* *Progonioclymenia acuticostata* *Kosmoclymenia serpentina*	*speciosa*
Gonioclymenia hoevelensis	*Gonioclymenia hoevelensis*		*hoevelensis*
Platyclymenia annulata	*Platyclymenia (P.) annulata*		*annulata*
Prolobites delphinus	*Prolobites delphinus*		*delphinus*
Pseudoclymenia sandbergeri	*Pseudoclymenia sandbergeri*		*dillensis*
Maeneceras pompeckji	*Maeneceras pompeckji*		*pompeckji*
Cheiloceras curvispina	*Cheiloceras amblylobum*		*curvispina*

and *Ch. amblylobum*.

Delépine (1929) recognised *Cyma. camerata* from the Étroeungt of Sémeries in northern France. Bouckaert, Dreesen and Drijkoningen (1978) reported a number of examples of *Cheiloceras* from the Souverain-Pré Formation of the Avesnois, northern France. They are too poorly illustrated for their identifications to be confirmed.

A possible means of correlating the Famennian of Belgium with the German Cephalopodenkalk sequence existed through the Famennian of the Aachen area on the west of the Rhine, and the Bergischesland and Velbert areas on the east, where the Etroeungt, at least, has long been recognised. Ammonoids have been reported from all of these three areas.(Schindewolf 1921, Wulff 1923, W. Schmidt 1956, Kasig *et al*. 1979, Jux and Krath 1974, Paeckelmann 1922, Paul 1939).

Ammonoid Zonation in the Famennian of the Rheinische Schiefergebirge

Early Schemes

Kayser (1873, p. 669) recognised two divisions of the Upper Devonian of the Rheinische Schiefergebirge by their ammonoid fauna, which he correlated with Gosselet's (1873) subdivision of the Upper Devonian of the Ardennes:

Kayser 1873	Gosselet 1873
Clymenien-stufe	Kalkstein von Étroeungt
Cypridinen-stufe	Sandstein von Condroz Schiefer der Famenne
Intumescens-stufe	Schiefer von Matagne mit *Cardiola retrostriata* Kalke and Mergel von Frasne (Cuboides-Schichten)

(from Kayser 1873, p. 654)

Ziegler's (1979) account seems to misinterpret the events surrounding this division of the Upper Devonian into an upper and lower part. He suggests (p. 42) that it was Kayser who first did this, but surely this was first achieved by Gosselet a few months previously (Gosselet 1873) since Kayser (1873, p. 654) quotes from Gosselet.

Kayser's twofold division of the Upper Devonian was based on the observation that the lower part contained distinctive goniatites, termed Primordiales (= Gephuroceratina), which were absent from the upper part. This, latter, was subdivided into a lower part containing a new and distinctive goniatite fauna (= Cheiloceratacea), and an upper part in which clymeniids first appeared. To these divisions Kayser gave the names Intumescens-Stufe, Cypridinen-Stufe and Clymenien-Stufe. He also suggested the name Münsteri-Stufe for this uppermost subdivision (Kayser 1873, p. 664). This name was adopted by Loewinson-Lessing (1892) who described a fauna from the eastern Urals which appears to range in age from the delphinus to subarmata Zones. No attempt was made, however, to integrate this zone in any scheme, nor to define its character, save perhaps, by implication the presence of Sp. (Sp.) muensteri.

A similar scheme was repeated by Frech (1887a, p. 438, 446). Here he recognised the lowest Frasnian G. lunulicosta Zone, and gave the name Stufe des Gon. curvispina (also named as Stufe des Gon. curvispina and Gon. subpartitus on p. 438) to the horizon containing a fauna of Simplices (tornoceratids and cheiloceratids) which lay above the Intumescens-Stufe (with a fauna of Primordiales), and below the Clymenien-Stufe (with a fauna of clymeniids and sporadoceratids). In the Lethaea Palaeozoica (Frech 1897, p. 176-8) Frech retained this four-fold division of the Upper Devonian.

Denckmann (1901a,b, Denckmann and Lotz 1901) was the first to attempt to divide the clymeniid faunas. Denckmann and Lotz (1901) recognised a similarity between the Upper Devonian faunas of the Kellerwald and the Sauerland. In the Balve area they reported a three-fold division of the Clymenienkalk: a lower division, a middle division, characterised by Cl. annulata, noticed in a quarry at Beil, and an upper division, characterised by Cl. speciosa and and Cl. laevigata. A fuller account (Denckmann 1901b) of the faunas from the Kellerwald used the explicit term "Zone der Clymenia annulata" and listed the following important species:

Enkeberger Kalk = Untere Clymenienkalk

- Prolobites delphinus
- Tornoceras simplex
- Brancoceras sulcatum
- Sporadoceras Münsteri
- Clymenia cf. laevigata
- Clymenia aff. striata

Zone der Clymenia annulata

- Clymenia annulata
- Cl. angustiseptata
- Cl. cf. laevigata

Dasberger Kalk = Oberer Clymenenkalk

- Clymenia annulata
- Cl. angustiseptata
- Cl. cf. laevigata

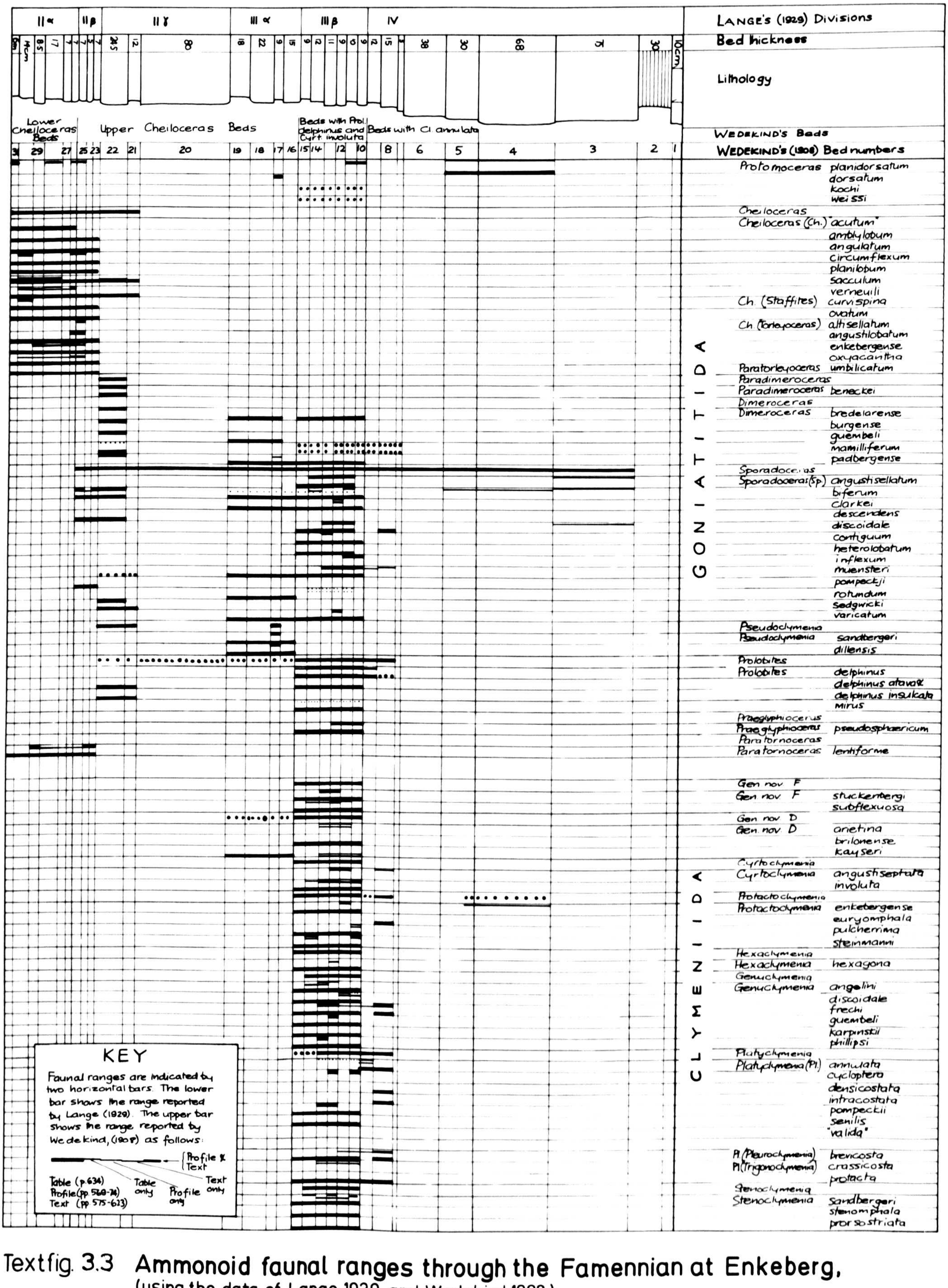
Frech (1902), provided supplementary information and subdivided the middle and upper Upper Devonian:

Clymenien Stufe	Zone der Gonioclymenien Zone der Clymenia annulata Zone der Pseudoclymenia Sandbergeri
Zone des Cheiloceras curvispina	

The Ch. curvispina Zone contained a fauna 99% of which was Cheiloceras, the Pseudoclymenia Sandbergeri Zone fauna included inter alia, Oxy. striata, Oxy. undulata, Ps. Sandbergeri, Prolobites delphinus, and Sporadoceras spp. Only Ps. Sandbergeri, T. planidorsatum and Cl. annulata were recorded from the Cl. annulata Zone. The uppermost Goniocly menien Zone contained, inter alia, Cl. solarioides, Pseudarietites, and Cl. laevigata, and Gonioclymenia spp. especially.

Wedekind's (1908) Enkeberg Section

A 9.2m trenched section through the Clymenienkalk of Enkeberg, Sauerland, was investigated by Wedekind (1908) in a systematic manner, collecting bed-by-bed. He was able to chart the precise ranges of most known Famennian ammonoids and he divided the succession into Beds by their fauna. The usefulness of his results is diminished by the discrepancies (House 1970) which can be found between his species ranges in the text, the table of faunal ranges (opposite p. 634), and the listing of the fauna bed-by-bed. (p. 569-71), and the condensed nature of the sequence. His results are summarised in Textfig. 3.3 and the important points it contains are picked out. The sequence was divided into Lower (Beds 31-26) and Upper Cheiloceras Beds (Beds 25-18 (p. 572) or 25-16 (table)) (this discrepancy is important since Bed 17 contains the first occurrence of Ps. sandbergeri); Beds with Clymenia involuta and Prolobites delphinus (Beds 14-10); and Beds with Clymenia annulata (Beds 9-4). Wedekind did not locate the Frasnian/Famennian or Intumescens-Stufe/Cheiloceras-Stufe, boundary nor did he specify which ammonoids enabled him to identify Bed 32 as Intumescens-Schichten. Wedekind had two attempts at analysing what he thought were the major faunal divisions at Enkeberg. On p. 572 he stated that the middle/upper Upper Devonian boundary was at Bed 17 (not above or below it) in which T. sandbergeri occurred. On p. 574 he listed three divisions: Beds with species of Cheiloceras, Beds



Textfig. 3.3 Ammonoid faunal ranges through the Famennian at Enkeberg,
(using the data of Lange 1929 and Wedekind 1908).

with species of Cheiloceras and Sporadoceras, and Beds with species of Sporadoceras and clymeniids.

The Lower Cheiloceras Beds were 6.53m thick although Bed 31, 6m thick, containing Protornoceras planidorsatum, and possibly Ch. sacculum (contrary information can be found on p. 571 and in the table) accounted for most of this. Cheiloceras (Ch.) verneuili and Torl. curvispina, and Ch. (Ch.) acutum were restricted to the Lower Cheiloceras Beds. Paratornoceras lentiforme appeared in Bed 29, and Lobotornoceras bilobatum in Bed 27. The boundary with the two metres thick Upper Cheiloceras Beds (25-?16) appears to have been marked by the incoming of Sp. (Sp.) biferum since no new cheiloceratids were recognised. Later, in Bed 22, numerous species of Dimeroceras first occurred, along with Maeneceras acutolaterale.

The uppermost boundary of Wedekind's Cheiloceras Beds is difficult to define. In the table he drew it between Beds 16 and 15, although according to this table no ammonoids were recorded with certainty from Beds 16 or 15, only from Beds 17 and 14. Wedekind appears to have interpreted the terms Clymenienschichten and obere Oberdevon as synonymous. Thus on p. 573 he states that the lower Clymenia Beds begin with dark brown limestones (Bed 14) containing Sp. (Sp.) biferum, numerous Prol. delphinus and two poorly preserved clymeniids, which are identified in the text (p. 615) and table as Prot. steinmanni (Wedekind). However, on the opposite page (p. 572) Wedekind seems to have been unable to accept the absence of cheiloceratids from levels within the Cheiloceras Beds. According to the table and on p. 571 numerous species of Cheiloceras are recorded from Bed 25. Thereafter in the table only Cheiloceras (Ch.) sacculum is recorded from Bed 22. This is confirmed in the text (p. 584) although not in the bed-by-bed faunal list. Beds 21 and 20 (0.92m thickness) contain no fauna, Pn. dorsatum is known from Bed 19 (faunal list, p. 572) although this is not confirmed by either the table or the text (p. 579) and the next horizon with a fauna is Bed 17 containing Ps. sandbergeri, Ps. dillensis, Pn. dorsatum and Dim. padbergense. Then there is a gap of 24cms until the next faunal horizon, Bed 14 in which Prol. delphinus appears. Wedekind chose the appearance of Ps. sandbergeri in Bed 17 to delimit the mittlere/obere Oberdevon boundary (p. 572). However, not thirty lines of text later, he contradicted this statement by placing the lower boundary of the obere Oberdevon between Beds 15 and 14.

It is possible that the problem arose because Wedekind felt he was unable to make Bed 17, just 9cms of limestone, into a distinct division (as Drevermann and Frech had done) even though it contained a distinctive species confined to that level. Consequently he maintained a conservative scheme, including the level in the Cheiloceras Beds (= mittlere oberdevon) and tried to retain the equivalence of obere Oberdevon and Clymenienschichten, yet at the same time mentioning, almost in passing, that the mid/upper Upper Devonian boundary was to be drawn at Bed 17, leaving it to the reader to take whichever of his contradictory statements he preferred.

The explanation of the higher parts of the sequence is slightly less complicated. Wedekind named Beds 14-10 (0.51m thick) as Schichten mit Prolobites Delphinus und Clymenia involuta. In the faunal list (p. 572) Bed 14 contains Cyrt. involuta, Prot. steinmanni and Sp. (Sp.) biferum. In the text Cyrt. involuta is not recorded from this level, although Prol. delphinus is (p. 590) and the table records with certainty only this species from Bed 14. It is not clear, therefore, from Wedekind's information, whether clymeniids appear in Bed 14, nor therefore, that Prol. delphinus appears simultaneously with them. The fauna in Bed 13 is much more diverse, and comprises Genu. frechi, Gen. Nov. D stuckenbergi (= lotzi Wedekind), Cyrt. (?) phillipsi, Cyrt. involuta, Plat. (Plat.) pompeckii, Sp. (Sp.) angustisellatum, Sp. (Sp.) contiguum, Sp. (Sp.) muensteri. Above this level more species of these genera were recognised. Also Gen. Nov. D subflexuosa and Praeglyphioceras pseudosphaericum appeared in Bed 12, and Plat. (Pleur.) brevicosta appeared in Bed 11. Stenoclymenia sandbergeri is recorded in the text and table from Beds 14 and 12, although only from Bed 10 in the faunal list (p. 570), and five examples of Cyma. costellata (Münster) (= Var. costata Wedekind) are recorded from Bed 11 in the table and text, though, again, not from the faunal list.

The upper part of the sequence at Enkeberg, ranging in age from IV to VIα, consisted of some three metres of dolomitic sandstone, which contained little fauna. This was divided into two parts, Beds 9-4 and Beds 3-1, and the boundary was drawn where Gonioclymenia appeared. Often the fossils were poorly preserved and Wedekind's identifications can only be questionably accepted.

The table shows Rect. roemeri, Prot. steinmanni, Genu. frechi, Rect. costa-protracta (Wedekind nom. nud. ? = Plat. (Trig.) protacta, Plat. (Pleur.) brevicosta and Prol. delphinus were present in Beds 9 and 8. This fauna is indicative of either IIIβ or IV. The only other acceptable records are of Cyma. sp. and Gon. (Kall.) subarmata from Bed 3. The faunal list (p. 569) gives more data and includes Cl. laevigata as low as Bed 8. No one else has recorded platyclymeniids and Clymenia sp. together.

Born (1912a)

Born (1912a) described a section through the upper Devonian from the Aeketal in the Harz. He used the terms ?annulata Zone (without himself finding any Plat. annulata), Zone des Prol.

delphinus and Cl. involuta (1912, p. 571), and Cheiloceras Schichten. He included a 24cms thick bed containing Torn. sandbergeri and Ch. cf. circumflexum in the Cheiloceras Schichten, and drew the boundary between this and the above zone below Bed 17 in which Cyrt. Wedekindi entered the sequence. Prolobites delphinus entered yet higher in Bed 21.

Wedekind's introduction of a zonal scheme (1913a,b, 1914, 1926)

In 1913 Wedekind (1913a) produced a zonation scheme for the Upper Devonian, introducing the notation of Roman numerals for the six Stufen and Greek letters for their subdivisions (zones). The Frasnian section was based on information mainly from Martenberg bei Adorf (Wedekind 1913b) and the Cheiloceras, Prolobites and part of the Postprolobites Stufen relied on information from Enkeberg. Wedekind merely retabulated his 1908 data for the lower Famennian dividing the Cheiloceras Stufe into two parts, a lower zone, IIα with Cheiloceras spp., and an upper part, IIβ, with Cheiloceras and Dimeroceras, (therefore, it is not clear whether he considered that Sporadoceras entered in IIα or IIβ). The horizon (Bed 17) containing Tornoceras sandbergeri and the Beds with Prolobites delphinus and Clymenia involuta were combined to form two zones of the Prolobites Stufe.

Only a sparse fauna was recorded from the upper parts of the sequence at Enkeberg, so to devise zones Wedekind investigated sections at Beil, Hövel and Dasberg near Balve, and incorporated his data with the outline scheme of Denckmann and Lotz (1901), which was based on collecting from localities in the same area, and from near Bad Wildungen. At first three Stufen were defined. The lowermost Postprolobites Stufe was the best known, and was divided into two zones, IVα Clymenia protacta, and IVβ Postprolobites frechi and Clymenia annulata. The other two Stufen were unnamed;

V was divided into three zones, the lower one was named Cl. laevigata and the middle one, Cl. bisulcata. Above this no precise information was given except to equate the terms, Stufe VI, Gonioclymenienkalke and Wocklumer Kalk.

By the end of 1914 three more schemes had been published, each incorporating minor revisions. Frech (1913) included in his catalogue of Devonian ammonoids a scheme which he acknowledged was based on information from Wedekind 1913a, then unpublished. It probably derived from a manuscript and therefore predates Wedekind's published version because the zonal index fossils for Stufen IV and V are different (see Textfig. 3.2) and the Gonioclymenienkalke consists of two Stufen, VI and VII.

Wedekind's second published scheme (1913b) included a boundary zone of Clymenia cf. striata between IVα and IVβ, based on information from Enkeberg and Burg and he considered that Cl. laevigata was still present in the middle zone of Stufe V, now named the Laevigata Stufe. A note indicated that IVβ faunas had been collected at Beil, Cl. laevigata Zone faunas from Hövel, and Cl. laevigata and Cl. bisulcata Zone faunas from Dasberg.

In 1914 Wedekind revised his zonal index fossils again; Plat. annulata var. densicosta and Plat. protacta in IVα and Postpr. frechi and Plat. valida (sensu Drevermann, non Phillips 1841) in IVβ, and no boundary zone between them. Stufe V was renamed Laevigata - Gonioclymenia Stufe and divided into two zones, Vα with Clymenia aegoceras and Laevigata hoevelensis and Vβ with Laevigates laevigata and Gon. tornquisti. The uppermost zone, identified as equivalent to the Fossley, was placed either in V or VI, and Stufe VI was named the Wocklumeria Stufe, comprising only one zone with Wock. denckmanni, Kall. subarmata and Oxy. wocklumeri.

Schindewolf (1916, 1921, 1923a) used Wedekind's Stufen and zonal names. He noted (1923a) that Wedekind had used Ch. subpartitum and Ch. enkebergense as zonal indices for the two divisions of the Cheiloceras Stufe (but these were not first published by Wedekind).

Schmidt (1921, 1924)

Working in the Warstein area Schmidt (1921) measured a complete section through Famennian at the Provinzialsteinbruch, Drewer. Although he gave ranges for various species he did not produce a zonal scheme. Paeckelmann and Schmidt (in Paeckelmann 1922) produced an alternative zonal scheme for the upper Famennian, based on Paeckelmann's stratigraphic researches in the Elberfeld region. Two Stufen were each divided into three zones:

Gonioclymenia Stufe	Zone of Wock. sphaeroides and Gl. glaucopis
	Zone of Gonioclymenia speciosa and Cymaclymenia ornata
	Zone of Gon. hoevelensis and Gon. torleyi
Platyclymenia Stufe	Zone of Clymenia annulata
	Zone of Clymenia involuta
	Zone of Pseudoclymenia Sandbergeri

Later Schmidt (1924) revised this scheme, adding, inter alia. a lowermost Carboniferous Postclymenia evoluta Zone, recognising a Sp. Pompeckji Zone above a Ch. curvispina Zone in the Cheiloceras Stufe, and renaming three other zones, namely: Wock. sphaeroides and Gl. glaucopis became Wock. sphaeroides and Gl. nucleus; Gon. hoevelensis and Gon. torleyi became Gon. hoevelensis and Plat. acuticostata; and Cl. involuta became Prol. delphinus.

Schindewolf (1937a) divided the Wocklumeria Stufe into a lower Kall. subarmata and Kall. brevispina Zone, and an upper Para. paradoxa Zone, further subdivided into an upper Wock. sphaeroides

Subzone, and a lower Kamp. endogona Subzone.

House (1962), in a summary table correlating European Devonian ammonoid Zones with newly introduced American Zones used a mixture of Schmidt and Schindewolf's zonal names in abbreviated form. Schindewolf's (1937a) Kall. subarmata Zone was used; other names were taken from Schmidt (1924).

Lange (1929)

The only other major contribution was made by Lange (1929) who over a period of years re-excavated Wedekind's Enkeberg section, collected from a trench through the Annulata-kalk at Beuel, and from a sequence ranging from doIII - V at Hövel. He produced a new zonal scheme but although he investigated the same sections as Wedekind it is not always easy to correlate their lithological divisions. Since Lange's faunal ranges were less precise than Wedekind's (see Textfig. 3.3) doubt has justifiably been shed on his results (House 1970).

Lately Korn (1981a) has collected from the Hövel section and sections nearby at Effenberg and Müssenberg, and produced a four-fold zonation of the Clymenia Stufe. Walliser (Alberti et al. 1974) examined a fauna collected from a trenched section through the Stockum Limestone. This was from a level with imitoceratids with openly umbilicate inner whorls, near the Devonian-Carboniferous boundary not present in the Hönnetal type-section and therefore not included in earlier zonal schemes. Its discovery has made the incoming of the distinctive Gattendorfia ammonoid fauna seem a much less clear-cut event and therefore made the actual position of the system boundary more difficult to define in terms of ammonoids. The name prorsum Zone has been applied to this level (Arbeitsgemeinschaft 1971).

All of these schemes are tabulated for ease of comparison in Textfig. 3.2 and are discussed Stufe by Stufe below. It will be obvious to the reader that all of the schemes were devised in Germany, and with one exception (Schindewolf 1916, 1923a) in the Sauerland. This is not because of a lack of well-preserved faunas elsewhere, nor the absence of useful sections, since the section in the Sauerland probably represents as thin a development of Famennian ammonoid bearing limestones as anywhere else in the world. Sequences in Poland (Dybczynski 1913, Sobolev 1914a,b) USSR (Perna 1914, Nalivkina 1936a,b, 1953, Bogoslovskiy 1969, 1971) North Africa (Petter 1959, 1960), Iran (Walliser 1966), China (Chang 1958, 1960, Ruan and He 1978), and Australia (Petersen 1975) were all treated from the standpoint of taxonomic description only, and the age ranges of the various taxa were stated only in terms of the German Stufen rather than being used to form independent zonal schemes. The blame for these missed opportunities can be laid on the apparent cosmopolitan nature of the faunas and the easily used carpet-bag nature of the taxonomic and Stufen nomenclature.

Cheiloceras Stufe doII

The Cheiloceras Stufe faunas of the Kirch-Gattendorf were described by Schindewolf (1916, 1923a, p. 270) from a section ca 14m thick. IIα was characterised by the occurrence of Cheiloceras subpartitum (Münster). He suggested (1923a, p. 271) that the boundary between IIα and IIβ was situated between Beds 4 and 5. In Bed 4 there was an increased frequency of Ch. (Ch.) pompeckji (Wedekind) and Ch. (Torl.) curvispina (Sandberger and Sandberger), and Ch. (Ch.) subpartitum was supposedly replaced by the thicker-whorled Ch. (Ch.) subpartitum crassum. Schindewolf did not find

Wedekind's IIβ zonal index, Ch. enkebergense, but considered Ch. aequisellatum and Ch. ultimum to represent similar levels since they had similar pointed lateral lobes and differed only in shell form, but he did not know from which bed his specimens came. In Bed 5 Ch. (Ch.) subpartitum crassum disappeared and Ch. (St.) pompeckji became less frequent. This was an extremely unsatisfactory way to draw a zonal boundary, yet Schindewolf mentioned only in passing (1923a, p. 272) that in Bed 5 appeared the first Dimeroceras and Sporadoceras. In fact according to Schindewolf's Table (p. 271) only Dim. guembeli and Paradimeroceras inflexum were recorded with certainty and there were no unequivocal records of Sp. (Sp.) biferum until Bed 8. This suggests that Dimeroceras appeared before Sporadoceras, contrary to the observations of Wedekind (1908) and Lange (1929), but little should be read into this because of the paucity of the fauna from Kirch-Gattendorf. However, a similar sequence was observed in better documented sections reported by Teichert (1941) and Petersen (1975) from the Canning Basin of Western Australia, particularly in a sequence over 250' thick (1975, table 1, labelled Ta-To). Here Paratornoceras, Dimeroceras spp. and Torleyoceras were recorded in the lower half of the section (Ta-Tm) and Sporadoceras occurred in the upper half.

Schmidt (1921, tab. III, fig. 2) described a 30m profile at Drewer from Iδ to the lower Carboniferous. The Cheiloceras Stufe amounted to 16m of limestone from levels 24-8. At level 19 he recorded two specimens of Ch. (Ch.) planilobum, level 18 contained numerous examples of Ch. (Ch.) amblylobum. Maeneceras pompeckji appeared at level 16, which Schmidt took as the index for IIβ and the zone was named as such in Schmidt's (1924, fig. 3) biostratigraphic scheme. He did not find Ch. (St.) pompeckji in level 8. Unfortunately he did not record Dimeroceras, nor any tornoceratids.

Lange re-excavated Wedekind's Enkeberg section (1929). He grouped his beds corresponding (almost) to Wedekind's divisions but did not document so precisely the measured section. Therefore accurate comparison is not possible. Although Lange recognised more species than Wedekind their ranges are less well defined. Cheiloceras (Ch.) acutum was the only cheiloceratid confined to IIα, and Lange named the zone after it. The base of IIβ was marked by the appearance of various species of Sporadoceras and Lange separated out an uppermost division, Beds 22-21, IIγ, the Dimeroceras benneckei Zone, where various species of Dimeroceras appeared. Notable records are: the presence in IIα of "cf. Imitoceras richteri", which cannot be accepted without question, since he did not state that he had observed the internal suture which alone permits discrimination of Imitoceras from Cheiloceras; and the presence in IIγ of Prol. delphinus var. atava and insulcata. Prolobites delphinus had been considered by Wedekind to mark the base of IIIβ.

Fuhrmann (1954) also discriminated a IIγ zone (Bed 10) in a section at Altestal (Blatt Zellerfeld, Harz) but he did not state how he had used this term. His zone IIβ (Bed 11) contained Dimeroceras spp. including Dim. benneckei and in his 0.26m thick Bed 10 (p. 636) Sp. (Sp.) muensteri and Dim. spp. including mammiliferum appeared.

House (1962) recognised in eastern North America Ch. (Ch.) amblylobum and Maeneceras cf. pompeckji which he interpreted as being from the lower and upper zones of Cheiloceras Stufe. Later House (1979) renamed the IIα zone as Cheiloceras amblylobum, presumably because this species appears to have a world-wide distribution and is the earliest occuring species of Cheiloceras in North America. Cheiloceras (Ch.) amblylobum is known from

Germany, Montagne Noire, Belgium, Poland (Gürich 1909, Sobolev 1914a,b), USSR (Novaya Zemlya, Nalivkina 1936a,b; Urals, Chernyshev 1887b, Perna 1914; Kazakhstan, Nalivkina 1953), China (Ruan 1978), North Africa (Petter 1959, 1960) and Australia (Glenister and Klapper 1966, Petersen 1975). Therefore it may be more suitable for use as an index fossil and perhaps can be used to define the Frasnian-Famennian boundary in terms of the ammonoid biostratigraphy. If it can be shown that Cheiloceras curvispina appears late in the Cheiloceras curvispina Zone, or that the Cheiloceras Stufe can be subdivided on the basis of other species of cheiloceratid, such as Ch. (Ch.) amblylobum, then various levels could be drawn within IIα resulting in the abandonment of the Cheiloceras curvispina Zone, or in its more precise definition. It is better, however, to retain the name Cheiloceras (Torl.) curvispina for the division of the Cheiloceras Stufe before the appearance of sporadoceratids, until such time as the faunas of the Cheiloceras Stufe are better documented. The occurrence of one Cheiloceras bearing level in the Famennian of eastern North America seems insufficient grounds to rename the lower zone of the Cheiloceras Stufe, although there can be no objection to its use within the context of the eastern North American succession.

Mention should also be made (see also Chapter 6) of the apparent presence of three species described as belonging to Manticoceras, in the Cheiloceras Stufe: M. superstes (Wedekind) and M. nehdense Lange, the former found at Kirch-Gattendorf (Schindewolf 1923a) and both found at Nehden, and M. niedzwiedzkii (Dybczynski) from Kielce (Holy Cross Mountains, Poland). These three species may in fact be synonymous and are all based on few specimens. It is considered that these species are members of the Tornoceratidae, and that the Gephuroceratina do not, on this evidence at least, extend to the Famennian (contra House 1979). (See Chapter

6, for a more lengthy discussion of these three species).

Platyclymenia Stufe doIII-IV

This name was first used explicitly by Lange (1929, p. 3) for the amalgamation of Wedekind's Prolobites and Postprolobites Stufen, because he had been unable to recognise these as major faunal divisions. Schindewolf (1923a, p. 284) had been unable to demonstrate at Kirch-Gattendorf Wedekind's twofold division of the Postprolobites Stufe and reported Postpro. yakowlevi Wedekind from the lower part and Plat. protacta from the upper part. These were Wedekind's index fossils for the upper and lower zones of the Postprolobites Stufe, respectively. Schmidt (1924, textfig. 3) amalgamated Wedekind's Stufen III and IV and divided it into three zones: α, Ps. Sandbergeri, β, Prol. delphinus and γ Plat. annulata.

Miller (1938) reported that Schindewolf intended to renumber the German Upper Devonian Stufen so that the Prolobites-Platyclymenia Stufe became III, Laevigates-Gonioclymenia IV, Wocklumeria V and Gattendorfia VI. This revised scheme was never used again and now Wedekind's numerical scheme is well entrenched in the German literature, even though II refers to a Stufe and IV to a zone. Clearly it is preferable to refer to the ammonoid biostratigraphic zonation of the Upper Devonian in terms of clearly defined zones and subzones, and until this is achieved the old nomenclature will persist.

The problems Wedekind (1908) encountered in delimiting the boundary between the middle and upper Upper Devonian have already been discussed (see above). The issue was clarified when he (Wedekind 1913a) divided the former obere Oberdevon into four Stufen and abandoned the term. The Prolobites Stufe was divided into two zones, the lower Tornoceras Sandbergeri Zone (IIIα), and the upper zone with Prolobites delphinus and Clymenia involuta, and this scheme has remained essentially unchanged (Frech 1913, Wedekind 1913b, 1914, 1926).

Schindewolf (1921, 1923a) considered that Prolobites delphinus was the most important indicator for IIIβ. He assigned 3.6m of limestone at Kirch-Gattendorf (Beds 9-12) to the Prolobites Stufe. Bed 9, a unit 1.2m thick, contained Ps. pseudogoniatites and other species of this genus, and Rect. kayseri (Drevermann), Cyrt. pulcherrima (Wedekind) and Genu. frechi. Sulcoclymenia entered in Bed 9 and Platyclymenia, Stenoclymenia and Trigonoclymenia in Bed 11. Unable to collect Prolobites, and finding only one specimen of Cyrt. involuta, in Bed 11, he put Bed 9 in IIIα and Beds 10-12 in IIIβ, drawing the boundary at Bed 10, where Pseudoclymenia disappeared from the record, rather than in Bed 11 where Cyrt. involuta first appeared, or within Bed 10, where other clymeniids were present.

Lange (1929, p. 15) also recorded clymeniids from IIIα. The evidence for this was that in 1906 during an excursion to Enkeberg led by von Koenen he had collected a piece of limestone containing Ps. pseudogoniatites (and therefore, he said, it presumably came from Bed 17) and Pn. dorsatum, and from the same piece of limestone von Koenen had broken off a sample which was now in the Göttingen Museum and contained the species Rect. kayseri. This evidence is indeed thin and unacceptable, but Lange renamed the IIIα zone as Platyclymenia kayseri (1929, p. 3).

Schindewolf's (1923a) record of clymeniids and Pseudoclymenia in the same bed can be explained by the 1.2m thickness of his unit Bed 9. Fuhrmann (1954, p. 642) recorded at Aeketal Var. kayseri, Ps. pseudogoniatites and Sporadoceras muensteri from his 1m thick Bed 5 and considered this as IIIα. However, since he did not specify that these ammonoids came from the same level within Bed 5 the conclusion that clymeniids occur in IIIα is not justified.

Lange recorded Prolobites delphinus tardesulcata Lange and Prol. delphinus striatus Lange from IIIα, and he also found Prol. delphinus atava and Prol. delphinus insulcata Lange in his IIγ zone. Therefore he could not use Prol. delphinus as the index for the base of IIIβ, and he renamed this as the Rectoclymenia subflexuosa and Cyrtoclymenia involuta Zone, the latter species being the most common clymeniid within it.

Wedekind divided the Postprolobites Stufe into two parts yet in none of his schemes (Wedekind 1913a,b, 1914, 1926; Frech 1913) did he use the same zonal indices. He explained the divisions (1914, p. 8), giving faunal lists for the two zones. On Enkeberg he encountered three species which he considered to be from zone IVα: Plat. (Trig.) protacta, Plat. (Plat.) annulata and Plat. (Plat.) annulata densicosta, (more are listed in his earlier report, 1908, p. 569, and by Lange (1929, p. 20)). Above this level (Beds 9 and 8) very few ammonoids were found. The upper zone IVβ, was encountered, therefore, not at Enkeberg but at Beil "beneath the Laevigatakalk" (Wedekind 1914, p. 8) and the rich fauna, from a section which has not been accurately documented, included many species of Platyclymenia and Postprolobites, hence the use of species of these genera as zonal indices.

Schindewolf (1923a, p. 284) considered the two zones to be indistinguishable. Lange (1929, p. 20) recorded Trig. protacta, Wedekind's IVα index from what he considered as IIIβ. Lange used the annulata Zone as a synonym of the Postprolobites Stufe which he renamed the Prionoceras divisum Unterstufe, since he recognised Postprolobites Wedekind to be a junior subjective synonym of Prionoceras Hyatt.

Practically no other biostratigraphic information is available for a discussion of the Platyclymenia Stufe even though rich faunas are known from elsewhere in the world and have been well illustrated (North Africa, Petter 1959,1960; Russia: Urals, Perna 1914, Kazakhstan, Nalivkina 1953; Iran, Walliser 1966; North America Montana, Raymond 1909). In the late 1920's Schindewolf dug a trench through this level near Bad Wildungen where he had earlier (1921) confirmed Wedekind's bipartite division of IV, although he never described the faunas. In Thuringia Müller (1956) described faunas from near Schleiz and Brügge (1973) extended his Alte Heerstrasse section up through the IV/V boundary. However, this interval remains poorly known (as are the faunas around the Frasnian/Famennian boundary) and faunas such as those described from Geuser by Münster 150 years ago can still not be incorporated into the biostratigraphic scheme.

Clymenia Stufe doV

Wedekind's early attempts to divide what were to be known later as the Clymenia and Wocklumeria Stufen met with little success, simply because this part of the succession at Enkeberg (Beds 9-1) was comparatively lacking in fauna. Subsequently he investigated sequences at Hövel, Dasberg, Burg and Borke-Wehr (Wocklum), all near Balve, but never published detailed sections of any localities.

When Wedekind established the Laevigata Stufe (Frech 1913) he divided it into three zones: Clymenia laevigata, Clymenia cf. undulata, and an unnamed zone, succeeded by the Gonioclymenienkalke (Stufen VI and VII) comprising the Fossley and the Wocklumer Kalk. In later schemes (Wedekind 1913a) Clymenia laevigata was retained as the index with Clymenia laevigata and bisulcata (1913a) and then Cl. bisulcata alone (1913b), for the middle zone. The upper zone remained unnamed but the Fossley was included in it

(1913a,b) and the Gonioclymenienkalke was renumbered as Stufe VI. Another scheme for the renamed Laevigata-Gonioclymenia Stufe was proposed in 1914 (Wedekind 1914). A lower zone Vα, was characterised by Clymenia aegoceras and Laevigites hoevelensis Wedekind, and an upper zone Vβ, by Laevigites laevigata (Münster) and Gonioclymenia tornquisti Wedekind. This scheme was retained in 1926 (Wedekind 1926).

The section published by Schindewolf at Kirch-Gattendorf (1923a) was the first to give bed-by-bed details of faunas from this level. In the Laevigites Stufe he recognised a lower zone, Vα, (Beds 15-17), with Laevigites hoevelensis and an upper zone, Vβ, (Beds 17-18), with Laevigites laevigata, confirming Wedekind's scheme. Besides the incoming of Clymenia in this Stufe, he also noted the appearance of Kosmoclymenia and Imitoceras.

Schmidt (1924) described the sequence across the Devonian-Carboniferous boundary in the Balve area. He introduced (1924, p. 108) a new threefold division, α, β, γ, for the uppermost part of the Devonian, the Dasberg Schichten. These zones were characterised by Gonioclymenia hoevelensis and Platyclymenia acuticostata, Gonioclymenia speciosa and Cymaclymenia ornata, and Wocklumeria sphaeroides and Glatziella nucleus Schmidt. This latter zone has been treated by all subsequent authors as the Wocklumeria Stufe.

Lange, working in the same area, at the same time as Schmidt, devised another scheme for his Orthoclymenia Stufe (1929, p. 5 & 26), using a profile through a quarry at Melschede (= Hövel of Wedekind 1914, and Ballberg of Ziegler 1962). He felt unable to accept Wedekind's distinction between Clymenia laevigata and Cl. hoevelensis, and considered them as one species. A lower, Va, Costaclymenia binodosa and Sellaclymenia torleyi Zone was added to Schmidt's two Gonioclymenia Zones, renumbered Vb and Vc, though Lange felt uncertain about recognising the upper speciosa Zone.

I have been unable to match Lange's published section with the outcrop at Hövel. Schindewolf used a series of names for V but did not add any biostratigraphic information: Orthoclymenia - Gonioclymenia (reported by Miller 1938), Oxyclymenia - Gonioclymenia (Schindewolf 1952) and finally (1957) Clymenia Stufe.

Recently Korn (1981a) has collected from the quarry section at Hövel, and from other sections nearby at Müssenberg and Effenberg, and proposed four zones: Kosmoclymenia serpentina, Progonioclymenia acuticostata, Piriclymenia piriformis and Ornatoclymenia ornata. He gave no details of faunal ranges, nor measured sections.

Wocklumeria Stufe doVI

Wedekind (1914, p. 10) recognised only one zone at this level, characterised by Wocklumeria denckmanni (Wedekind), Kalloclymenia subarmata (Münster) and Oxyclymenia Wocklumeri Wedekind. He gave only cursory account of these faunas from Burg, near Balve.

Schindewolf's (1916) study of the profile at Kirch-Gattendorf included a division of the Wocklumeria Stufe. A lower VIα Wocklumeria sp. nov. Zone, and an upper VIβ Wocklumeria Denckmanni Zone were recognised. However, Schindewolf did not actually find Wocklumeria and he later modified his scheme (Schindewolf 1923a). He included Bed 22 (with a fauna of Kosmoclymenia, Sellaclymenia, Cymaclymenia and Cyrtoclymenia) and Bed 21 (with a fauna of Imitoceras and Gattendorfia) in a new division, the Gattendorfia Stufe (VI), and presumed that above this came the Wocklumeria Stufe (VII), which was absent. Therefore it seems that Wocklumeria sp. nov. Schindewolf 1916 was later recognised by Schindewolf as Gattendorfia subinvoluta, and used to name a new Stufe.

Schmidt (1924, p. 169) pointed out that Schindewolf had inverted Stufen VI and VII, and thus he revised his stratigraphy accordingly (Schindewolf 1926, p. 94). Schmidt (1924) drew the base of the Carboniferous at the base of the Hangenberg Schiefer. Schindewolf (1926) placed the base of the Carboniferous above the Gattendorfia Stufe, but later lowered it (Jongmans and Gothan 1937) to the base of the Gattendorfia Stufe, that is to the base of the Hangenbergkalk above the Hangenberg Schiefer at Oberrödinghausen.

Schindewolf (1937a) produced an extremely detailed study of the Wocklumeria Stufe faunas, principally from the railway-cutting at Oberrödinghausen near Menden, and established a series of new zones and subzones based on the precisely charted ranges of many species (1937a, p. 27-29). The Parawocklumeria paradoxa and and Kamptoclymenia endogona Subzones were both recognised by Selwood (1960) at Launceston in Cornwall.

The base of the Wocklumeria Stufe has not been clearly defined. Schindewolf named his lower Wocklumeria Stufe division as the Kalloclymenia subarmata and brevispina Zone, although he did not identify the former species from the Oberrödinghausen section. A likely explanation of this is the poorly known nature of this species. The boundary between Stufen V and VI appears to have been drawn by Schindewolf between Beds 22 and 23 on the basis of a possible occurrence of Kall. brevispina in Bed 22. However, many authors (e.g. Eickhoff 1973) have taken the base of Schindewolf's (1937a) section, i.e. the base of Bed 23, as the base of the Wocklumeria Stufe.

It is possible that Gon. (Kall.) subarmata occurs in the Clymenia Stufe. Certainly the subgenus Gon. (Kalloclymenia) has been found in association with other ammonoids of that age at Landlake, Cornwall (Kall. insignis Phillips; Selwood 1960), Hövel (Kall. dasbergensis and crassa, Wedekind 1914, p. 9), and Beil (see Gonioclymenia (Kalloclymenia), Chapter 5).

The lower Hangenbergschiefer at Oberrödinghausen and Drewer contains _Cyma_. _evoluta_, _Kosmo_. _wocklumeri_ and _Gon_. (_Kall_.) _wocklumensis_ (Schindewolf 1937a) but above this only species of _Imitoceras_ and _Acutimitoceras_ occur until the incoming of the _Gattendorfia_ Stufe faunas in the Hangenbergkalk. The Stockum Limestone, occurring locally as thin limestone lenses in the upper Hangenbergschiefer of the Balve area, but unfortunately not in the Oberrödinghausen section, contains a distinctive _Protognathodus_ conodont fauna (Koch _et al_. 1970; Alberti _et al_. 1974) and goniatite fauna which includes _Acutimitoceras prorsum_ and _Acut_. _carinatum_. _Acutimitoceras prorsum prorsum_ has early whorls which are openly umbilicate, an umbilical lobe which is centred outside the umbilical seam and biconvex growth-lines, and thus is considered as transitional between _Imitoceras_ and _Gattendorfia_. In short there has been argument over whether this fauna has greater affinity with the Carboniferous than the Devonian, and similar arguments exist for transitional taxa in other fossil groups. The name _prorsum_ Zone has been applied to this level (Arbeitsgemeinschaft 1971). House (1979) used _Prionoceras_ spp. instead. Korn (1981b) described a similar fauna from Müssenberg.

Rationalisation of zonal names

The reader who believes he has followed everything in this account so far deserves credit. It should be evident however, that some standardisation in the use of zonal names is desirable. The practice of recognising the priority of specific zonal names has long been in operation in the Mesozoic systems (e.g. Arkell 1946) and this will be done here. Unfortunately German stratigraphers do not operate in this way, especially those who were responsible for devising the conodont zonation, with which the ammonoid zonal scheme is most often compared and correlated.

Zones will be listed in chronological order, starting from the base of the Famennian. Problems arise for those zones for which some doubt exists over the validity or usage of the index, particularly *sandbergeri*, *annulata* and *euryomphala*.

curvispina Zone IIα

This was first used as a zonal name by Frech (1902), and was applied to faunas collected at Nehden and to 20m (Bed 6) of a continuous section at La Serre, Cabrières, Hérault. The zone was characterised at Nehden by the overwhelming predominance of species of *Cheiloceras* (1000 examples), compared with only "two *Gephyoceras*, four *Sporadoceras* and two *Aganides*". These latter specimens are considered to have been misidentified, especially the *Aganides* (= *Imitoceras*), which was illustrated in pl. IV(III), fig. 16a, where it clearly lacks the extra internal lobe which would distinguish it from *Cheiloceras*.

The zonal index is *Torleyoceras curvispina* and the zone corresponds to the range of *Cheiloceras* before the entry of *Maeneceras* or *Sporadoceras*. Schindewolf's (1916) *subpartitum* Zone is considered as synonymous. It was established in Oberfranken, in a ?different faunal province and may deserve local usage there. The same comment can be applied to the *amblylobum* Zone (House 1962), used for a level in the Gowanda Shale, New York State.

No formal subzones have been used within the *curvispina* Zone. However, certain faunal levels are widely recognisable, and these may ultimately deserve subzonal status. They are discussed below.

pompeckji Zone IIβ

The name holding priority for a zone above the *curvispina* Zone is Schindewolf's (1916) *enkebergense* Zone. This is not used here because it was established in Oberfranken rather than in the

Rheinische Schiefergebirge. Schindewolf (1923) considered that its base was marked by the appearance of Ch. (Ch.) subpartitum crassum, which has an only slightly different whorl section from Ch. (Ch.) subpartitum subpartitum. Therefore Schmidt's pompeckji Zone is used.

This was first recognised at Drewer, by the entry of Maeneceras pompeckji. This level has also been recognised at Enkeberg (1908) where the entry of index is accompanied by Sp. (Sp.) biferum and clarkei, and in New York State (House 1962). For this study at Beil only Sp. (Sp.) biferum was recorded (See Chapter 7), and this may prove a more useful means of defining the base of the zone, although Schmidt (1924, p. 109) believed that the entry of biferum succeeded pompeckji (1921, taf. III). He placed it in IIIα, but this date is questionable since he did not record Pseudoclymenia at Drewer.

sandbergeri Zone IIIα

This name was first used by Frech (1902) but was not clearly defined until Frech (1913) or Wedekind (1913a) introduced the overlying delphinus Zone. Then it became clear that it was characterised by the appearance of Pseudoclymenia. No section was associated with the recognition of this zone, except by implication, Enkeberg, which was the only place where it had been recorded in situ (Wedekind 1908).

The taxonomic status of the index Gon. sandbergeri has not been made clear before. It was first used by Gümbel (1862, p. 289) who credited Beyrich with authorship. No precise reference was cited, but Beyrich (1859) had drawn attention to the fact that Cl. pseudogoniatites Sandberger 1853 was a true goniatite, and thus had an inappropriate name. Therefore sandbergeri Gümbel can be interpreted as an invalid replacement for pseudogoniatites, but nowhere in Gümbel's account was this explicitly stated. It has been widely interpreted by reference to Frech's (1902, pl. III(II), fig. 18) illustration. Gümbel (1862), Kayser (1873) and Drevermann (1901) had illustrated only the suture, sufficient only to identify Pseudoclymenia.

It is desirable that this zone should be renamed, in which case Schindewolf's (1921) drevermanni Zone is available. This specific name is an invalid replacement for dillensis Drevermann 1901, which should, therefore, be used instead. Pseudoclymenia dillensis appears to be a useful marker for this zone, whatever its name. No subdivision within this zone has been proposed, although the earliest clymeniid occurs here.

delphinus Zone IIIβ

This name was first used by Schmidt (1924) as a contraction of Frech's (1913) Prol. delphinus and Cl. involuta Zone. The index is Prolobites delphinus and in this account its range has been interpreted by reference to Wedekind's (1908) section at Enkeberg. Here the base of the zone seems clearly defined by the entry of the index. Other authors have found this to be a less clear-cut event (see below).

annulata Zone IV

This name was first used by Denckmann and Lotz (1901), referring specifically to an outcrop in a quarry at Beil. Wedekind (1913a-1926) had several attempts at subdividing this zone. Schmidt (1924) and Lange (1929) did not believe that there was sufficient evidence to do this. None of Wedekind's subzones is considered to be practically applicable here.

The identity of the index species annulata Münster is discussed below, in Chapter 5. The conclusion reached is that it has been interpreted sensu richteri Wedekind. Hence this species is used as the marker for the base of the annulata Zone.

Clymenia Stufe V

The division between this and the underlying annulata Zone has long been recognised by the entry of the first complex sutured clymeniids, namely: Gonioclymenia, Costaclymenia and Kosmoclymenia. Wedekind chose as zonal indices for his lower and upper divisions of the Clymenia Stufe hoevelensis and laevigata, two species of Clymenia. They were recognised as subjective synonyms by Lange, and that opinion is confirmed below (see Chapter 5). Furthermore collection at Hövel indicates that Clymenia laevigata is confined to the middle of the Clymenia Stufe. Consequently it is proposed that Wedekind's zonal names be abandoned.

Priority devolves upon names introduced by Schmidt (1924). He used a lower division of Gon. hoevelensis and Plat. acuticostata and an upper division of Gon. speciosa and Cyma. ornata, observed on and near Dasberg. Species of Gonioclymenia are rare, poorly defined, and being highly ornate would seem prone to high specific variability. It may prove inappropriate to use the Gonioclymenia species as zonal names, in which case those species named secondly by Schmidt deserve priority.

Lange (1929) introduced a binodosa Zone, lowermost in the Clymenia Stufe. Korn (1981a) introduced a fourfold zonation of the Clymenia Stufe, using in part Schmidt's names acuticostata and ornata. The section at Hövel in which Lange defined his binodosa Zone cannot be related to the outcrop visible today (see Chapter 7). Korn's (1981a) zonal scheme was not accompanied by any details of in situ collecting, but was based on observations at Hövel, Effenberg and Dasberg.

hoevelensis Zone Vα

This zone was introduced by Schmidt (1924) and has Gon. (Gon.)

hoevelensis as its index. The base is undefined. Korn recognised two levels within the zone, which he named serpentina Zone and acuticostata Zone, based, by implication, on the appearance of these two species. It is argued in the systematic section (Chapter 5) that the species acuticostata Münster has been wrongly interpreted in the Rheinische Schiefergebirge. Examples from there are better referred to the species aegoceras Wedekind, which would serve as the marker for the acuticostata Zone.

speciosa Zone Vβ

This zone was introduced by Schmidt (1924) and has as its index Gon. (Gon.) speciosa. Its limits are undefined. Korn recognised two zones within it, named ornata and piriformis, but these, if used, would be better treated as subzones. The indices are rare and have an homeomorphic shell form and are difficult to distinguish without view of the suture. Adequate means of recognising these two divisions were not proposed.

Wocklumeria Stufe VI

Faunal horizons within this Stufe are clearly defined, thanks to the precise documentation of Schindewolf (1937a). However, the boundaries with the adjoining Stufen were not clearly stated. Schindewolf utilised two zonal names: a lower Kall. subarmata and brevispina Zone, and an upper Para. paradoxa Zone. Kalloclymenia subarmata is considered inappropriate as an index because it is not clearly distinguishable from other species of Gon. (Kalloclymenia) s.s., and may range down into the Clymenia Stufe. Hence the more distinctive Gon. (Subgen. Nov. A) brevispina is preferred. Usage of a paradoxa Zone, including a sphaeroides Subzone seems synonymous, at least in part, with Paeckelmann and Schmidt's (in Paeckelmann 1922) Wock. sphaeroides and Glatz. glaucopis Zone. Therefore it should be abandoned in favour of the prior sphaeroides Zone.

brevispina Zone

This zone was first used by Schindewolf (1937a). The index is Gon. (Subgen. Nov. A) brevispina Lange. The base is recognised by the entry of the index, and this was recorded by Schindewolf at Bed 22 in the Oberrödinghausen railway-cutting section. No subdivisions have been proposed for this zone.

sphaeroides Zone

This name was first used by Paeckelmann and Schmidt (in Paeckelmann 1922), presumably using evidence from their work at Dasberg and in the Hönnetal (Schmidt 1924). The index is Wock. sphaeroides, the occurrence of which is restricted to the middle, sphaeroides Subzone.

Three divisions are recognised. The lowest is the endogona Subzone. The index for this is Kampt. endogona and the base of the subzone is defined by the entry of Para. paradoxa, recognised at Bed 10 in Schindewolf's (1937a) Oberrödinghausen section.

The name sphaeroides as a subzone was applied by Schindewolf (1937a). Its base was defined by the entry of the index in Bed 4 at Oberrödinghausen.

Schindewolf did not give a name for his uppermost faunal division at Oberrödinghausen. This was termed the "Schichten mit Cyma. euryomphala" and was applied to the Hangenberg Schiefer. The first explicit use as a zone occurs in Arbeitsgemeinschaft (1971) where it appears in a table, and is correlated with the lower part of the Hangenberg Schiefer. House (1978) has given this name zonal status, but it is treated here as a subzone, The name euryomphala is newly recognised here (Chapter 5) as an invalid replacement for evoluta Schmidt, after which this subzone should now be named.

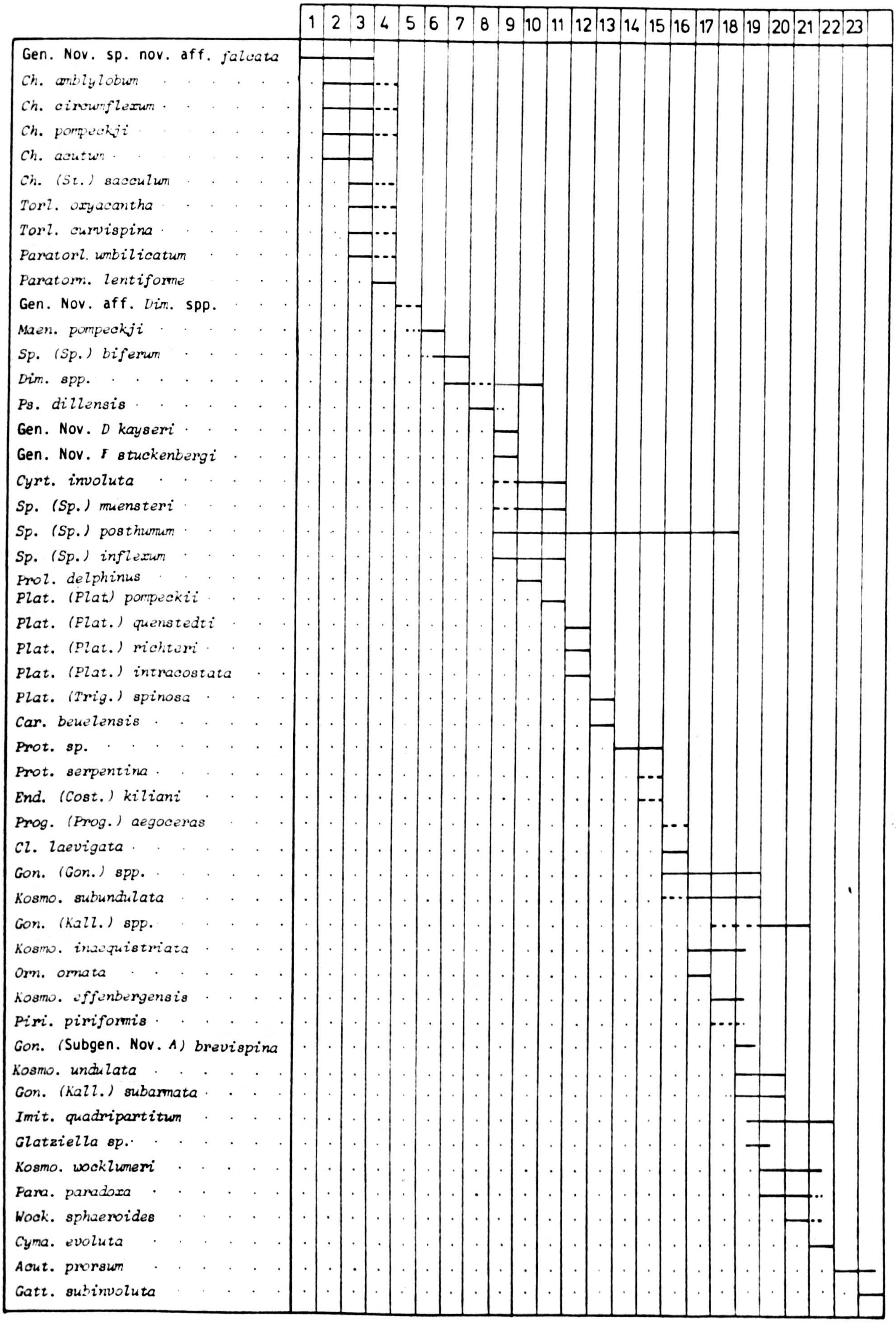
prorsum Zone

This name was first used in Arbeitsgemeinschaft (1971), but was not clearly defined. The index, and associated species of Acutimitoceras, are well known from an horizon known as the Stockum Limestone, recognised at two localities in the Sauerland, but not in the Oberrödinghausen section. The index is Acutimitoceras prorsum prorsum, the appearance of which defines its base. The zone is characterised by a fauna of Acutimitoceras spp. and lacks clymeniids. Co-occurring is a conodont fauna known as the upper Protognathodus fauna (see Chapter 6). Currently this is believed (Alberti et al. 1974) to lie within the sulcata (conodont) Zone and thus to be Carboniferous in age, but this question is not finally resolved.

The prorsum Zone is a very short interval, and once it is placed either in the Carboniferous or Devonian, it should be incorporated as a subzone within either the subinvoluta or sphaeroides Zones. The base of the subinvoluta Zone (and its lower acutum Subzone) is currently defined by the entry of Gatt. subinvoluta, recognised in Bed 6 of Vöhringer's (1960) Oberrödinghausen section. Recently Walliser (in Paproth and Streel 1982, p. 34,36) has drawn attention to a unit below Vöhringer's measured section, and has suggested that the basal 10cms of Bed 6 lacks Gatt. subinvoluta, although he did not state which goniatites were present.

Faunal levels recognised within the Famennian

The faunal ranges presented here (Textfigs. 7.11,17), when taken in conjunction with the data of Wedekind (1908, Textfig. 3,3), Schmidt (1921) and Schindewolf (1937a) allow some 23 faunal levels to be recognised within the Famennian (Textfig. 3.4). This is



Textfig. 3.4 Range chart showing the 23 faunal levels recognised in the Famennian. Based mainly on Textfigs. 3.3, 7.11, 7.17 and Schindewolf 1937a.

seen as a first step to erecting subzones.

curvispina Zone Levels 1-?5

The best evidence for level 1 comes from the Montagne Noire where recent work by myself and M.R. House has shown that a distinctive ribbed tornoceratid (Gen. Nov. sp. nov. aff. *falcata* Frech) enters the record after the last occurrence of a manticoceratid, and before the appearance of *Cheiloceras*. This species has also been recorded from Guadalmez (Spain, Groth 1914), Thuringia (Zimmerman 1893), Brittany (Frech 1897) and Nehden (Frech 1897).

Level 2 is marked by the entry of *Cheiloceras*. First the simple-sutured species *Ch. subpartitum amblylobum*, *planilobum verneuili*, *acutum* appear. This level was not recognised *in situ* at Beil, and has been observed only at Nehden, and in the Montagne Noire.

In Level 3 the more complex-sutured cheiloceratids *Torl. curvispina*, *oxyacantha* and *Paratorleyoceras umbilicatum* appear. These have an extra internal lobe. Both the section at Beil, and Wedekind's (1908) data commence at this level.

The entry of *Paratornoceras lentiforme*, a distinctive oxyconic goniatite, marks Level 4. This horizon has been reported from Enkeberg (Wedekind 1908), Holy Cross Mountains (Sobolev 1914a,b), n. Urals (Nalivkina 1936b) and is newly recorded here from the Montagne Noire. Unfortunately this species was not collected *in situ* at Beil, where the relevant part of the section coincides with the gap in the trench exposure (Textfig. 7.21).

Gen. Nov. aff. *Dimeroceras* was recorded from Beil in Bed 14, and marks Level 5. This taxon is distinguished from *Dimeroceras* by the presence of a lobe centred near to the umbilical seam, rather than near the mid-flank. It has also been recognised in the Canning Basin, where Petersen (1975) dated his specimens as from the overlying pompeckji Zone. Sporadoceras primaevum and Imitoceras sp., reported from the North West Territories by House and Pedder (1963), probably both belong in this genus.

pompeckji Zone Levels 6,7

Level 6 is recognised by the incoming of Sporadoceras, although which species serves best as a marker for the base is still not certain (see above).

Wedekind (1908) recorded the appearance of Dimeroceras after Sporadoceras (Textfig. 3.3), and this may mark an upper division of the pompeckji Zone, Level 7. The formal name, benneckei, from Lange (1929), is available for this. No faunas were collected from this level at Beil.

dillensis Zone Level 8

Level 8 is already widely recognised as the horizon where Pseudoclymenia appears.

delphinus Zone Levels 9-11

Details of subdivisions within this zone have already been given. Level 9 is marked by the incoming of clymeniids; Gen. Nov. D stuckenbergi and kayseri seem to be the earliest widely recorded species. The former appears in Bed 42 at Beil, and both Schindewolf (1923) and Lange (1929) reported the latter from around this level. Level 10 is marked by the appearance of Prol. delphinus. Sporadoceras (Sporadoceras) muensteri and Cyrt. involuta are two common species characterising this level. Platyclymenia enters the record in Level 11.

annulata Zone Levels 12-14

Three faunal levels within the annulata Zone were all recognisable at Beil. Platyclymenia (Plat.) richteri and other strongly ornamented forms all appear in Level 12. The distinctive species *Plat*. (*Trig*.) *spinosa* and *Carinoclymenia beuelensis* mark Level 13 and *Protoxyclymenia* appears in Level 14.

Further evidence for Level 14 comes in the section at Hövel (see Chapter 7), and in faunas collected at Wäschholz, where *Aktuboclymenia* also occurs.

Clymenia Stufe Levels 15-18

Korn (1981a) named four zones within this Stufe, and four faunal levels are recognised. However, the two schemes cannot be correlated since Korn gave no details of faunal ranges, except for species of *Cymaclymenia*.

The lowest Level, 15, has a fauna including *Pro. serpentina* and *End*. (*Cost*.) *kiliani*, although neither was recognised in this study at Hövel. Level 16 contains a fauna including *Kosmo. subundulata*, *Prog*. (*Prog*.) *aegoceras*, *Cyma*. *costellata*, *Gon*. (*Gon*.) *hoevelensis* and *Cl*. *laevigata*, all of which enter the record here. The upper two levels, 17,18, corresponding to the *speciosa* Zone, are distinguished by the species *Kosmoclymenia* they contain; *inaequistriata* in 17, and *effenbergensis* (Korn and Price in prep.) in 18.

Wocklumeria Stufe Levels 19-23

The ranges of species within this Stufe are well known (Schindewolf 1937a). Level 19 corresponds to Schindewolf's *subarmata* Zone, although the appearance of *Gon*. (Subgen. Nov. *A*) *brevispina* is used to mark the base. The entry of *Glatziella* in the middle of the level could be used to make a further subdivision. *Parawocklumeria paradoxa* marks Level 20, and *Wocklumeria sphaeroides* Level 21. These are both easily recognisable widely occurring species. Level 22, marked by *Cyma*. *evoluta*, is characterised more by the absence of taxa, than the appearance of new forms. Schindewolf (1937a) considered there to be four or five clymeniids in the early part of the level (= lower Hangenberg Schiefer) but only evoluta occurs in the upper part. In Level 23 there are only species of Acutimitoceras. Interestingly Imitoceras, known from above and below, has not been recorded here.

Chapter 4

Classification, phylogeny and evolution of the Clymeniida

Early Classification of the Clymeniida

Early classification schemes: Münster, von Buch and Sandberger

In modern times (i.e. post-Schindewolf 1923b) classification schemes dealing with the Clymeniida have been published by the following authors: Bogoslovskiy (1955, 1975, 1979b, 1981), Delépine (1952), Korn (1981a), Miller (1938), Miller and Furnish (1954), Ruzhencev (1957, 1960, 1962), Schindewolf (1924, 1928, 1937a, 1939, 1949a, 1955, 1957, 1972). Reviews of the development of the classification of the Clymeniida have been published by Bogoslovskiy (1981), and Schindewolf (1949a).

Early attempts to classify this diverse group of cephalopods, united by the presence of a dorsally situated siphuncle (Textfig. 4.2b), were based on the morphology of the septa. Münster (1832) made two divisions of the genus _Planulites_ (renamed _Clymenia_ in 1834): a group with weakly curved and rounded lateral lobes (comprising the species _laevigatus_, _pygmeus_, _angustiseptatus_, _compressus_ and _inflatus_), and another group with pointed lobes and rounded saddles (comprising the species _planorbiformis_, _undulatus_, _sublaevis_, _inaequistriatus_, _linearis_, _parvulus_, _serpentinus_ and _striatus_). Further discoveries (Münster 1839) of species of _Clymenia_ meant that this classification scheme had to be modified to accept more complex forms. A third group was introduced to accommodate clymeniids with two lateral lobes (comprising the species _bilobata_, _angulosa_, _semicostata_).

Leopold von Buch (1838, p. 159) divided the clymeniids into two groups, _adscendentes_ and _incumbentes_, in the following way:

Adscendentes, species with a saddle at the umbilical seam (actually defined by a lateral saddle rising to the umbilical seam).
Incumbentes, species with a lobe at the umbilical seam e.g. *Cl. striata* (actually defined by a lateral saddle *falling* to the umbilical seam).

This classification was revised and extended by Sandberger (1853, p. 212):

Clymeniae arcuatae, species with roundly curved lateral lobes (comprising the species *compressa*, *binodosa*, *arietina* and *subnautilina*).
Clymeniae angulatae, species with pointed lateral lobes.
Adscendentes, as defined by von Buch (comprising the species *laevigata*, *undulata*).
Incumbentes, as defined by von Buch, (*Cl. pseudogoniatites*).

Gümbel (1863) undertook a major revision of the clymeniids, based mainly on the specimens from Münster's Collection which had passed to the Bavarian State Collections in Munich. He devised a classificatory scheme with far more divisions than that of von Buch, returning to the approach used by Münster, but refining it. There were three major categories, termed Gruppen or Untergattungen, and these were subdivided at a further two levels.

Euclymenieae, species without a continuous siphuncular tube (i.e. without contiguous septal necks).
Cyrtoclymeniae, species with a single, roundly curved, lateral lobe.
Sublobatae, with a shallow, wide, lateral lobe, rising uninterrupted to a saddle at the umbilical seam (comprising the species *angustiseptata*, *flexuosa*, *annulata* and *spinosa*).
Longilobatae, with a deep, rounded, lateral lobe and a sickle-shaped inner lateral saddle (*Cl. binodosa*).

Genuflexilobatae, with a curved lateral lobe modified by a pointed base and a simple saddle at the umbilical seam (comprising the species dunkeri, laevigata).

Oxyclymeniae, species with a single deeply pointed lateral lobe.

Adscendentes, with a saddle at the umbilical seam (Cl. undulata).

Incumbentes, with a lobe at the umbilical seam (Cl. striata).

Cymaclymeniae, with two lateral lobes of equal depth (Cl. bilobata).

Nothoclymenieae, species with a continuous siphuncular tube (i.e. with contiguous septal necks).

Sellaclymeniae, species with a ventral saddle and evolute whorls (Cl. angulosa).

Gonioclymeniae, species with a ventral lobe and evolute whorls (comprising the species speciosa, subarmata, intermedia, beaumonti*).

Discoclymeniae, species with a ventral lobe and involute whorls (Cl. haueri*).

Cycloclymenieae, species with a continuous siphuncular tube, ventral lobe, and almost cylindrical, evolute whorls (Cl. planorbiformis*).

(* these are all now recognised to be goniatites).

Hyatt: recognition of families

Hyatt (1884, p. 312-4) revised Gümbel's groups (of rank lower than subgenera) Cyrtoclymeniae, Oxyclymeniae, Cymaclymeniae, Sellaclymeniae and Gonioclymeniae, and gave them generic status as Cyrtoclymenia, Oxyclymenia, Cymaclymenia, Sellaclymenia and Gonioclymenia. He acknowledged his debt to Gümbel by saying

(1884, p. 313) "We...., use his names .... without making any claim ... of having originated them", but by a decision of the ICZN (Opinion 182) Hyatt was declared to be formal author of these generic names since he had been the first to use them in the nominative singular, as laid down by Article 8 of the Code.

Hyatt (1884) divided the clymeniids into 3 families:

Cyrtoclymenidae	Cyrtoclymenia Oxyclymenia Platyclymenia
Cymaclymenidae	Cymaclymenia Sellaclymenia
Gonioclymenidae	Cryptoclymenia Cycloclymenia Gonioclymenia Discoclymenia

These he grouped into the Suborder Gastrocampylii (Hyatt in Eastman-Zittel, 1900, p. 547) which was replacement for the name Intrasiphonata which Zittel (1895, p. 396) had used without indicating its taxonomic rank, describing it vaguely as a group. He was unsure of the affinities of the clymeniids and dealt with them in a footnote.

Hyatt also suppressed, without justification or explanation, the genus Clymenia and this caused a taxonomic problem which has remained unsolved in the literature, even though Schindewolf discussed it on many occasions (1923a, 1949a, 1955, 1972).

The generic name Clymenia was revived by Frech (1902, p. 29) who claimed that Münster (1832, 1843) had given prominence to the species laevigatus/a as the type of the genera Planulites and Clymenia. Further developments in the usage of the name Clymenia are described later (see Chapter 5). Frech (1902, p. 28) used the term Clymeniae (Intrasiphonata) but referred to this group as a family.

Edwards (1849, p. 21, 50) introduced the first supra-generic classification of the clymeniids when he erroneously included Clymenia with the nautiloid genus Aturia in the family Clymenidae. As the rules (Code) currently stand the author of a family is not automatically credited with authorship of groups of higher rank. Thus Wedekind (1914) is the author of Order Clymeniida etc., and not Edwards.

Wedekind (1908, p. 604) took Gümbel's group Cyrtoclymeniae and subdivided it on the basis of his observations of clymeniids collected from a measured sequence at Enkeberg in the Rheinische Schiefergebirge.

Cyrtoclymeniae sublobata	Rectoclymeniae Protactoclymeniae Varioclymeniae
Cyrtoclymeniae genuflexibiliae	Genuclymeniae Orthoclymeniae

(N.B. genuflexibiliae may be a misquotation of genuflexilobatae Gümbel, 1863, p. 118).

He referred, in headings, to Rectoclymenia, Protactoclymenia etc. as genera but referred to all species as Clymenia in his descriptions, thus not making clear the relationship between it and his new generic names.

A more formal approach can be found in Wedekind's (1914) monograph on the clymeniids of the Rheinische Schiefergebirge, where he treated the clymeniids as a suborder (Clymeniacea) of the Order Ammonoidea, and was the first author to afford them formal supra-familial rank. Thus Wedekind, rather than Hyatt, is credited with the authorship of both the Order Clymeniida and the Suborder Clymeniina (contra Schindewolf 1957, Ruzhencev 1957) rather than Hyatt, who had given no indication of the rank of his Clymeninae. The current rules (<u>Code</u>) do not cover taxa of supra-familial rank, and offer no guidance on this point. Wedekind divided the Clymeniacea into three families by their growth-lines, shell form and suture. He recognised two groups, one with biconvex growth-lines, subdivided by the nature of the coiling into Cymaclymeniidae (involute) and Platyclymeniidae (evolute), and another group with straight growth-lines, Gonioclymeniidae.

Cymaclymeniidae	<u>Rectoclymenia</u>
	<u>Protactoclymenia</u> (<u>Protactoclymenia</u>)
	<u>Protactoclymenia</u> (<u>Genuclymenia</u>)
	<u>Cyrtoclymenia</u>
	<u>Cymaclymenia</u>
Platyclymeniidae	<u>Varioclymenia</u>
	<u>Platyclymenia</u>
	<u>Laevigites</u>
	<u>Oxyclymenia</u>
Gonioclymeniidae	<u>Sellaclymenia</u>
	<u>Gonioclymenia</u>
	<u>Kalloclymenia</u>

Later Wedekind (1917) devised a scheme in which he separated the ammonoids into three orders, Palaeo-, Meso-, and Neoammonoidea, discriminated by the presence or absence of frilling ("Inzisionen") on lobes and saddles. The clymeniids should therefore have fallen within the Palaeoammonoidea, but were not discussed explicitly.

<u>Schindewolf: Introduction of ontogenetic considerations</u>

The next reviser of the clymeniids was Schindewolf (1923a) who introduced ontogenetic, and hence supposed phylogenetic considerations in a short paper (1923b) which clarified the taxonomic position of genera he had introduced earlier (1923a). The Clymenoidea were treated as an order, with two suborders, Gonioclymeniacea and Platyclymeniacea (Textfig. 4.1), the distinction between which was not based solely on simple morphological criteria, but rather on differences in ontogenetic development. The presence of a ventral lobe was considered a primitive characteristic, since the earliest supposed clymeniid, Acanthoclymenia, possessed one (House 1961, showed that this anomalous, middle Frasnian genus was in fact a manticoceratid) and because the earliest septa of clymeniids had a ventral lobe (Kosmoclymenia, Branco 1880, Cymaclymenia, Schindewolf 1923b). The Gonioclymeniacea retained a ventral lobe throughout ontogeny, and were considered as progressive; Platyclymeniacea lost their ventral lobe early in ontogeny, it being replaced by a saddle, and were termed regressive. The picture is, of course, more complicated than envisaged, but this argument has been used to divide the clymeniids into two groups ever since.

Two families within the Gonioclymeniacea were recognised; Gonioclymeniidae, with an undivided ventral lobe, and Sellaclymeniidae, in which the ventral lobe is divided by a saddle. Division into genera was based on sutural formula and aspects of the shell-form and ornament.

Subdivision into families within the Platyclymeniacea was based on a combination of the character shell-form, coiling and growth-line shape. Within the Cymaclymeniidae and Rectoclymeniidae genera were distinguished by their sutural formula, but within the Platyclymeniidae by the shape of sutural elements or by shell ornament.

SCHINDEWOLF 1923B

Order CLYMENOIDEA

Suborder GONIOCLYMENIACEA
Family Gonioclymeniidae
Hexaclymenia
Acanthoclymenia
Costaclymenia
Gonioclymenia
Kalloclymenia
Otoclymenia
Schizoclymenia
Sphenoclymenia

Family Sellaclymeniidae
Sellaclymenia
Biloclymenia

Suborder PLATYCLYMENIACEA
Family Platyclymeniidae
Varioclymenia
Platyclymenia
Laevigites
Protoxyclymenia
Oxyclymenia

Family Cymaclymeniidae
Cyrtoclymenia
Genuclymenia
Cymaclymenia
Biloclymenia

Family Rectoclymeniidae
Rectoclymenia
Falciclymenia

SCHINDEWOLF 1957

Suborder CLYMENIINA

Superfamily GONIOCLYMENIACEAE
Family Hexaclymeniidae
Hexaclymenia
Progonioclymenia
Soliclymenia

Family Acanthoclymeniidae
Acanthoclymenia

Family Gonioclymeniidae
Costaclymenia
Gonioclymenia
Kalloclymenia
Kall. (Kalloclymenia)
Kall. (Otoclymenia)
Sphenoclymenia
Sellaclymenia

Family Wocklumeriidae
Pachyclymenia
?Miroclymenia
Wocklumeria
Epiwocklumeria
Biloclymenia

Family Glatziellidae
Glatziella
Postglatziella

Superfamily CLYMENIACEAE
Family Clymeniidae
Platyclymenia
Plat. (Platyclymenia)
Plat. (Pleuroclymenia)
Plat. (Trigonoclymenia)
Clymenia
Piriclymenia
?Trochoclymenia
Protoxyclymenia
Kosmoclymenia

Family Cyrtoclymeniidae
Cyrtoclymenia
Genuclymenia
Cymaclymenia

Family Rectoclymeniidae
Rectoclymenia
Falciclymenia

Superfamily PARAWOCKLUMERIACEAE
Family Parawocklumeriidae
Kamptoclymenia
Triaclymenia
Parawocklumeria

BOGOSLOVSKIY 1981

Order CLYMENIIDA
Suborder GONIOCLYMENIINA

Superfamily SELLACLYMENIACEAE
Family Hexaclymeniidae
Hexaclymenia
Soliclymenia
Progonioclymenia

Family Costaclymeniidae
Costaclymenia
Mesoclymenia

Family Sellaclymeniidae
Sellaclymenia

Family Miroclymeniidae
Uraloclymenia
Pachyclymenia
Miroclymenia

Family Biloclymeniidae
Kiaclymenia
Biloclymenia
Riphaeoclymenia

Family Wocklumeriidae
Wocklumeria
Epiwocklumeria
Synwocklumeria

Family Gonioclymeniidae
Gonioclymenia
Schizoclymenia
Sphenoclymenia
Kalloclymenia
Kall. (Kalloclymenia)
Kall. (Otoclymenia)

Superfamily PARAWOCKLUMERIACEAE
Family Parawocklumeriidae
Kamptoclymenia
Triaclymenia
Parawocklumeria

Suborder CLYMENIINA

Superfamily CLYMENIACEAE
Family Cyrtoclymeniidae
Cyrtoclymenia
Platyclymenia
Plat. (Platyclymenia)
Plat. (Pleuroclymenia)
Plat. (Trigonoclymenia)
Plat. (Spinoclymenia)
Stenoclymenia
Trochoclymenia
Sulcoclymenia
Piriclymenia

Family Rectoclymeniidae
Rectoclymenia
Falciclymenia
Cteroclymenia

Family Carinoclymeniidae
Carinoclymenia
Acriclymenia
Pinacoclymenia

Family Clymeniidae
Aktuboclymenia
Protoxyclymenia
Kosmoclymenia
Clymenia

Family Cymaclymeniidae
Genuclymenia
Cymaclymenia
Ornatoclymenia
Kazakhoclymenia
Laganoclymenia

TEXTFIG. 4.1. Former clymeniid classification schemes.

Schindewolf (1923b, textfig., p. 62) produced a phylogenetic scheme for the clymeniids, which differs little from that presented here, except for the omission of then unrecognised genera. Lange (1929) used the same scheme of classification as Schindewolf.

Schindewolf (1934) revised the genus Platyclymenia, recognising three subgenera (Platyclymenia, Trigonoclymenia and Pleuroclymenia) distinguished by their growth-line shape (Textfig. 4.12). Precise collecting at Oberrödinghausen enabled Schindewolf (1937a) to produce a detailed study of the gonioclymeniid faunas of the Wocklumeria Stufe, particularly four families, Wocklumeriidae, Glatziellidae, Hexaclymeniidae and the Parawocklumeriidae. (The new family Parawocklumeridae, was then placed within the Platyclymenidae, distinguished by its suture in which both ventral and dorsal lobes were replaced by saddles).

Treatise schemes: Schindewolf and Ruzhencev

Schindewolf's final ideas on the classification of the Suborder Clymeniida were expressed in the Treatise (Schindewolf 1957). This incorporated newly established taxa within his earlier (1923b) scheme, with renaming where appropriate (Textfig. 4.1).

Preparation of the Russian Treatise (Ruzhencev 1957, 1960; Bogoslovskiy 1962), and the study of Devonian ammonoids in the USSR (Bogoslovskiy 1955 et seq.) prompted the development of an alternative classification scheme (Textfig. 4.1). This treats the Clymeniida as an Order, and thus permits an extra rank in the hierarchy.

The main distinction between the Russian and German schemes is in the composition of some families. Schindewolf (1957) included Costaclymenia, Gonioclymenia, Kalloclymenia and Sellaclymenia within the Gonioclymeniidae, whereas Ruzhencev (1960) placed them in three separate families, Costaclymeniidae, Gonioclymeniidae and Sellaclymeniidae, and the Gonioclymeniidae were put into a separate superfamily. Groupings within the Clymeniaceae/ Clymeniina were also quite different; where Schindewolf had only two families, Clymeniidae and Cyrtoclymeniidae, Ruzhencev had three, Clymeniidae, Cyrtoclymeniidae and Cymaclymeniidae. Exact generic composition of these families can be seen in Textfig. 4.1. Essentially Ruzhencev considered that Cyrtoclymenia had an affinity with Platyclymenia rather than Cymaclymenia; Schindewolf took the opposite view. During the last 25 years Bogoslovskiy (1955 et seq.) has erected some 12 genera, and has enlarged the classification scheme to accommodate them.

Bogoslovskiy's scheme is used here (Textfigs. 4.4, 4.5), but with some modification of the taxonomic rank by the use of subfamilies along the lines introduced by Schindewolf (1928) and Weyer (1981). Within the Gonioclymeniina families comprise genera showing a common pattern of sutural elaboration; genera are distinguished primarily by sutural formula, and subgenera by differences in whorl form, or major ornament. Within the Clymeniina such a rigid approach cannot be adopted. Sutural pattern is much simpler and genera tend to be distinguished by relatively minor differences in sutural pattern, often by the shape of individual elements, and families contain genera with a common shell-form or growth-line course. Thus differences which in the Clymeniina would serve to separate genera can in the Gonioclymeniina only separate species.

Future Work

This classification can only be usefully improved when two important sets of data are obtained: a greater understanding of the ontogeny of clymeniids, and precise stratigraphic ranges of genera and species. To date the ontogenies of only Kosmoclymenia (Schindewolf 1923b) and Gen. Nov. C (Bogoslovskiy 1955) are known, to which can be added here Cymaclymenia (Textfig. 4.15). Schindewolf (1937a) provided partial sutural ontogenies of a number of genera. Details of the stratigraphic ranges of early genera would be particularly important in unravelling the evolution of the clymeniids in the delphinus and annulata Zones, by which time most families had already appeared. Identification of the earliest clymeniid species should shed evidence on whence the group is derived.

Evolution of the Clymeniida

Origin of the Clymeniida

Arguments surrounding the origin of the Clymeniida were summarised by House (1970, 1981a) and Schindewolf (1972). Two major hypotheses have been advanced.

Archoceras - Hexaclymenia

Schindewolf (1932, 1933, 1972), following an idea initiated by Hyatt (1884), derived Hexaclymenia from Archoceras, the grounds for this being their near homeomorphy, with the exception of their siphuncular position, ventral in Archoceras, dorsal in Hexaclymenia (Textfig. 4.3a). Branco (1880, pl. VII, fig. 3b) had figured a clymeniid with a siphuncle in the ventral position at the first septum. Schindewolf (1923b), has stated that the

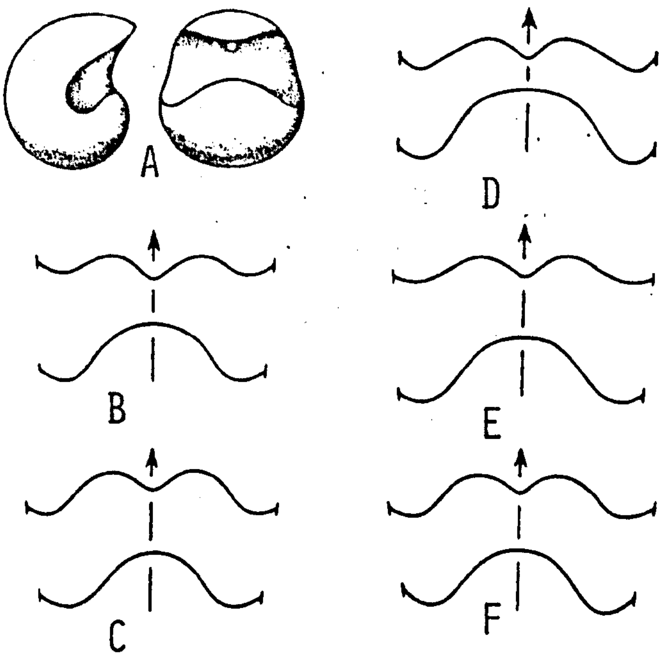
Textfig. 4.2a Prosuture and first septum of various clymeniid species (after Bogoslovskiy 1976). A, B protoconch, and proseptum and first septum of _Cymaclymenia evoluta_ (after Schindewolf 1923b); C, _Protoxyclymenia_ cf. _serpentina_; D, Gen. Nov. _F subflexuosa_; E, _Genuclymenia frechi_; F, _Genuclymenia angelini_; all X40.

2b Cross-sections of the early whorls of clymeniids (after Bogoslovskiy 1976): A, _Genuclymenia frechi_; B, _Cyrtoclymenia frechi_; C, _Platyclymenia richteri_; D, _Pachyclymenia intermedia_; all X45. Each illustration shows the dorsad migration of the siphuncle, achieved by the third septum.

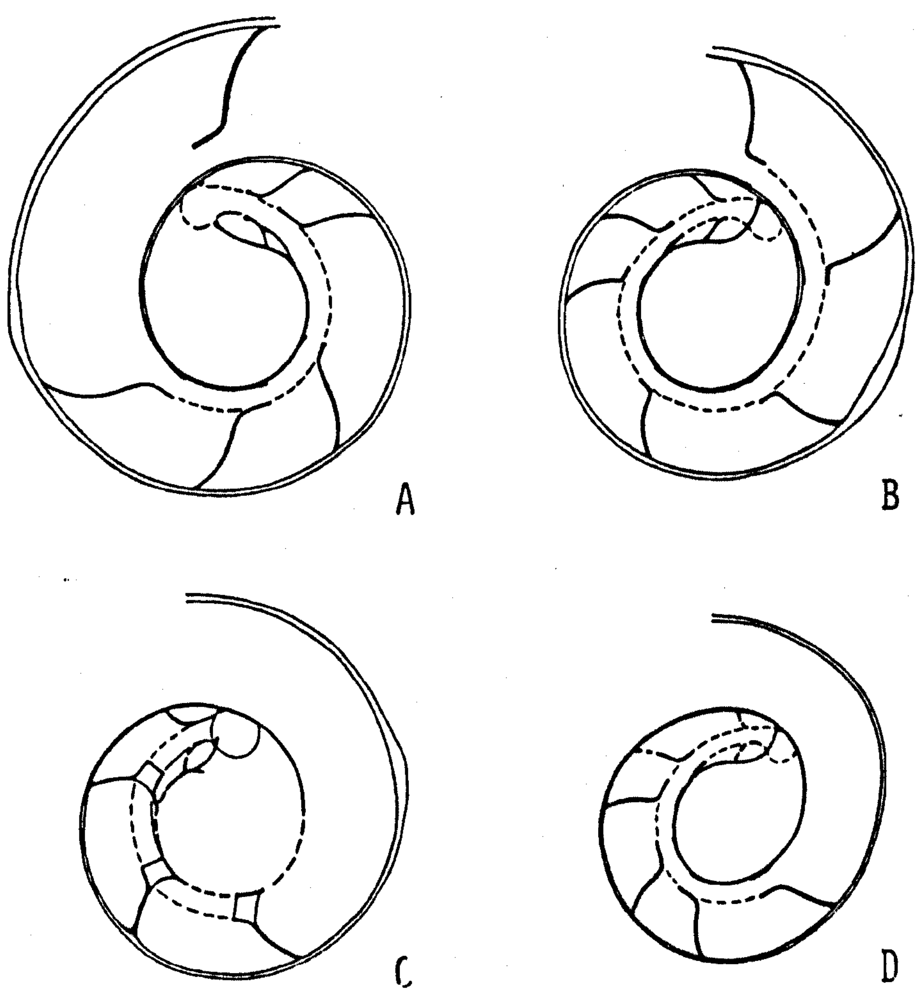
Textfig. 4.3b House's (1970) theory for the derivation of the Clymeniida from _Tornoceras_ via _Protornoceras_ and _Tornia_, by increasing evolution of the shell form, flattening of the lateral lobe, and, finally, migration of the siphuncle. ?_Protactoclymenia humboldti_ (A) has been selected from Sobolev's (1914a) illustrations of the Kielce fauna from which House obtained the specimens he illustrated to support his theory. A, ?_Protactoclymenia humboldti_ (after Sobolev 1914a, fig. 118 and pl. IX, fig. 30 (X2)); B, _Tornia mirabile_ (after House 1970, textfig. 2A and pl. 126, fig. 4 (X2)); C, _Protornoceras_ aff. _zuberi_ (after House 1970, textfig. 2B, pl. 126, fig. 2 (X3)); D, _Protornoceras simplificatum_ (after House 1970, textfig. 2C, pl. 125, fig. 5 (X3)); _Protornoceras dorsoplanum_ (after Sobolev 1914a, pl. IX, fig. 36a (X1)); E, _Tornoceras_ aff. _crebriseptum_ (after House 1970, textfig. 2D, pl. 125, fig. 4 (X2)).

Textfig. 4.2

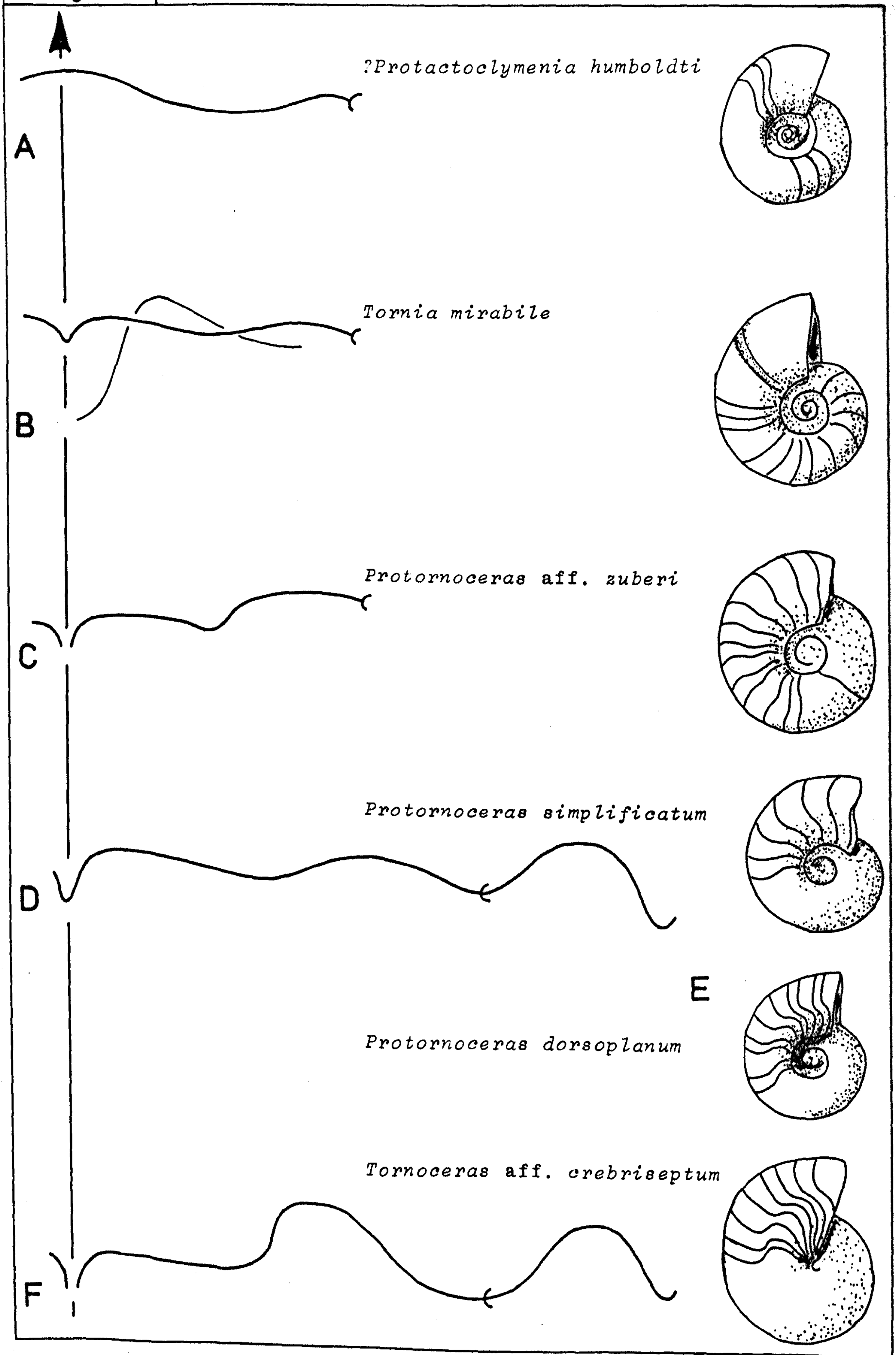
a



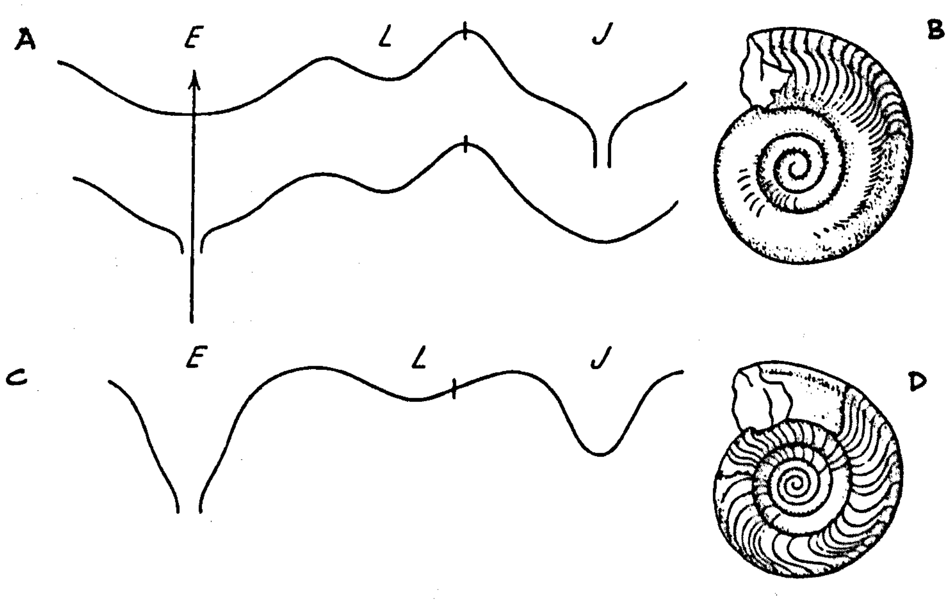
b



Textfig. 4.3b


?Protactoclymenia humboldti
A
Tornia mirabile
B
Protornoceras aff. zuberi
C
Protornoceras simplificatum
D
E
Protornoceras dorsoplanum
Tornoceras aff. crebriseptum
F

siphuncle in the clymeniids changes position from ventral to dorsal over the course of the first three septa, which view was substantiated by the beautifully prepared sections of Bogoslovskiy (1976), Textfig. 4.2a. Schindewolf also considered Hexaclymenia to represent the earliest stage of evolution within the clymeniids, since it has the simplest sutural formula of the Gonioclymeniina, the group in which the ventral lobe is retained throughout ontogeny. At this time Acanthoclymenia was considered to be the earliest clymeniid (Schindewolf 1934) and the middle Frasnian Archoceras seemed a plausible choice as its ancestor. When House (1962) recognised that Acanthoclymenia was not a Frasnian clymeniid, attention could be focused solely on the early clymeniids of the middle Famennian (?delphinus Zone).



Textfig. 4.3a. Schindewolf's (1972) theory for the origin of the Clymeniida. All magnifications are unknown, (from Schindewolf 1972, abb. 3).
Archoceras paeckelmanni, A, suture; B, side view.
Hexaclymenia hexagona, Ci, ii, suture; D, side view.

The youngest Archoceras is known from the lower Famennian curvispina Zone, yet Hexaclymenia is not known until later, in the *delphinus* Zone (Bed 12, Enkeberg, Wedekind 1908). The earliest clymeniids that Wedekind recorded were *Stenoclymenia sandbergeri* (Bed 12), *Platyclymenia* (*Plat*.) *pompeckii*, *Cyrtoclymenia involuta*, Gen. Nov. *F* lotzi, *Genuclymenia phillipsi*, *Genu. frechi* and *Genu. angelini*, all from Bed 14, *delphinus* Zone, thus representing a diverse fauna. Lange (1929) reported *Rect*. *kayseri* from the *pseudogoniatites* Zone.

Tornoceras - *Tornia* - *clymeniids*.

It was to these apparently earlier clymeniids, with simpler sutures, that House (1970) turned when he argued that the Tornoceratidae, via *Tornoceras* (*T*.) *crebriseptum*, *Protornoceras* and *Tornia*, all known from the *sandbergeri* or *delphinus* Zones, gave rise to the "earliest clymeniids" (Textfig. 4.3b). These have a shell form and suture similar to *Tornia*, especially *Stenoclymenia*, *Platyclymenia* and *Protactoclymenia*.

House (1970, p. 673) neatly summarises six reasons to support his argument for the derivation of the clymeniids from *Tornoceras*, rather than *Archoceras* or nautiloids. These were (with my comments in brackets): the similarity of the egg-shaped protoconchs of the clymeniids and *Tornoceras* (the Anarcestina, of which *Archoceras* is a member, also have egg-shaped protoconchs); the lack of an umbilical perforation in both clymeniids and *Tornoceras* (*Archoceras* has no umbilical perforation); the migration of the siphuncle from a ventral to dorsal position, early in ontogeny (there is a ventral siphuncle in all goniatites); and recognition of a series of tornoceratid species which show a transition in shell-form and sutural shape, between *Tornoceras* and clymeniids (*Archoceras* and *Hexaclymenia* have the same shell-form).

A strong argument against accepting that migration of the siphuncle could take place in _Archoceras_, is the shape of the septum (House 1970, 1980a). This in _Archoceras_ is convex orad (Schindewolf 1937b, pl. 19, fig. 1b) and has a lateral saddle as the dominant element. In early clymeniids (_Cyrtoclymenia_, _Platyclymenia_) the septum is concave orad and dominated by the broad lateral lobe.

Little has been added to these arguments since that date. Schindewolf (1972) and Bogoslovskiy (1976) rejected House's opinion, maintaining that the sutures of _Archoceras_ and _Hexaclymenia_ were homologous, both having the formula EL:I (i.e. Schindewolf's (1954) U-type), whereas the sutures of _Tornia_ and _Platyclymenia_ are merely homeomorphic, their formulae being EAL:I (i.e. A-type, in which the adventive lobe is derived from secondary splitting of the lateral saddle) and L:I (U-type) respectively, meaning that the lateral lobe is Adventitious in _Tornia_, but truly Lateral in _Platyclymenia_. It should be added that for none of these four particular genera is the sutural ontogeny known, but is presumed from knowledge of similar, and related, tornoceratids and clymeniids.

Bogoslovskiy (1976) ably demonstrated that in clymeniids the siphuncle migrated from a ventral to a dorsal position during early ontogeny (Textfig. 4.2). Drushchits and Doguzhayeva (in Drushchits _et al._ 1976) argued that the Clymeniina were derived from the Tornoceratina because in that group the position of the siphuncle is unstable, unlike the Anarcestina (of which _Archoceras_ is a member) in which it is stable.

House's argument is appealing. The evolution of _Archoceras_ into a clymeniid requires:

1 reversal of the septal face

2 migration of the siphuncle

3 discovery of a transitional species to bridge the

stratigraphic gap between the curvispina and delphinus Zones.

But the evolution of Tornia into a clymeniid requires only:

1 migration of the siphuncle

However the arguments of Schindewolf (1972) and Bogoslovskiy (1976), concerning sutural ontogeny, are difficult to ignore. In the clymeniids the prosuture develops into a first suture with a lateral lobe near the umbilicus, migrates across the flank towards the venter (e.g. Kosmoclymenia, Textfig. 4.2b and Schindewolf 1923b; Cymaclymenia, Textfig. 5.31F-I). In Tornoceras (and by inference in the closely related genera Protornoceras and Tornia) the lateral lobe is formed by the division of the ventrad flank of the lateral saddle, and it migrates across the flank towards the umbilicus (Bogoslovskiy 1971, fig. 7), and the umbilical lobe remains centred on the umbilical seam. This fundamental difference in sutural ontogeny between Tornoceras and the clymeniids, central to the way in which the Ammonoidea are subdivided into orders (Wiedmann and Kullmann 1980), amounts to an overwhelming objection to House's theory.

Alternative Theories

Sobolev (1914a,b) considered that the clymeniids were polyphyletic, each being derived from a goniatite with a similar suture. Ten such lineages were proposed, all involving migration of the siphuncle from the venter to the dorsum. Thus Cymaclymenia striata was described as being derived from Pseudoclymenia, Cyrtoclymenia angustiseptata from Tornoceras simplex etc. The confusion implicit in this system was compounded by the introduction of new generic, and, subsequently (1925), specific/subspecific names, which were indicative of a species' position in one of the ten lineages, and also of its morphology. Thus *Cheiloceras tenue* Sobolev, at first became *Oma-monameroceras* (*Cheiloceras*) *tenue* Sobolev, and then, *Oma-amblylobites sub-galeatus-retrovaricatus* f. *tenuis-subinterrupti-genuvaricata-spirostriata* Sobolev, *Tornoceras siemiradzkii* Dybcynskii became *Gomi-umbo-gony-re-amblylobites dorsatus-dorsovaricatus-subcostatus* f. *subumbilicatum* Sobolev, and *Cyrtoclymenia* aff. *plicata* (Münster) became *Umbo-cyrtolobia* (*Alobia*) *globularis-subcorrecti-lineata?-subcostata* Sobolev f. *sub-umbilicata* Sobolev. Such theory and nomenclatorial practice has met with little support in modern times (only Termier & Termier 1948 have supported a polyphyletic origin for the clymeniids) and Schindewolf was instrumental in having Sobolev's genera (though not his species) declared invalid by a ruling of the ICZN, (Opinion 132, Schindewolf *et al*. 1936).

Flower (1961) and Donovan (1964) maintained that clymeniids were derived from coiled nautiloids.

Classification and Phylogeny

A classification scheme is shown in Textfig. 4.4 and some phylogenetic links are shown on the range chart (Textfig. 4.5). The Order Clymeniida is subdivided into two Suborders, Gonioclymeniina and Clymeniina. In the first group the ventral lobe is retained throughout ontogeny, although in some families (see below) it is lost secondarily. In the Clymeniina the ventral lobe is lost early in ontogeny.

Suborder Gonioclymeniina

This group is subdivided into three superfamilies: Sellaclymeniaceae, Parawocklumeriaceae and Gonioclymeniaceae. In the first group sutural elaboration takes place either by division of the ventral lobe by a saddle, or by addition of umbilical lobes. In the second the dorsal lobe is replaced by a saddle, and in the third a deep ventral lobe is retained throughout ontogeny, and sutural elaboration takes place by addition of both Adventive and Umbilical lobes.

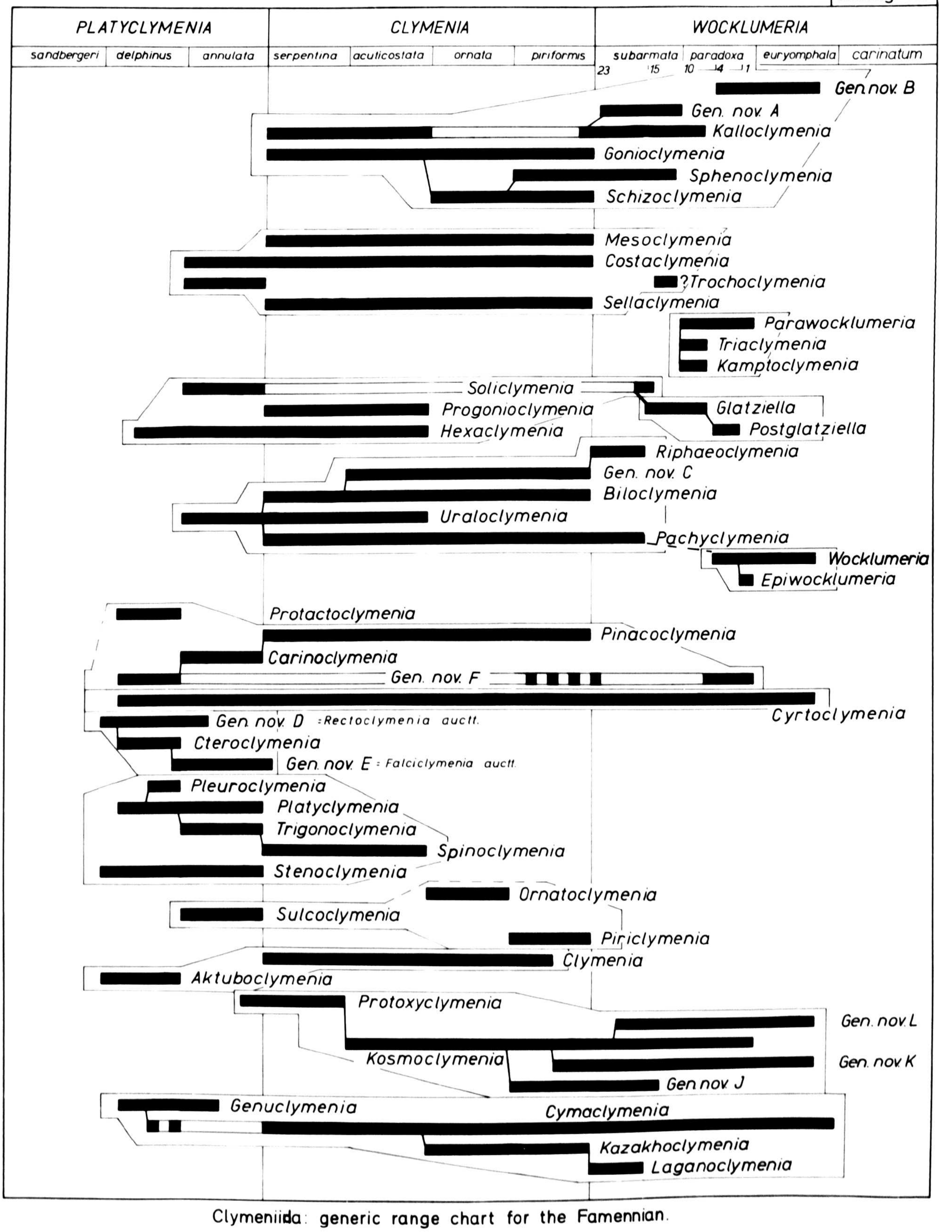
Sellaclymeniaceae

Three families are recognised: Glatziellidae, Sellaclymeniidae and Biloclymeniidae. The Glatziellidae have a simple suture consisting of a ventral lobe (sometimes divided by a saddle) a lateral lobe, and a dorsal lobe, and sometimes an umbilical lobe. Growth-lines are concavo-convex. Sellaclymeniidae are evolute, have a ventral lobe (sometimes divided by a saddle), a large lateral lobe and umbilical and dorsal lobes. Growth-lines are S-shaped. The Biloclymeniidae are subinvolute with a suture

Superfamily	Family	Subfamily	Genus	Sutural formula
SELLACLYMENIACEAE	Hexaclymeniidae	Hexaclymeniinae	*Hexaclymenia*	EL:I
			Progonioclymenia((Prog.)	L:I
			Prog. (Soliclymenia)	EL:I
		Glatziellinae	*Glatziella*	$(E_1E_1)L:I$
			Postglatziella	$(E_1E_1)LU:I$
	Costaclymeniidae	Costaclymeniinae	*Costaclymenia (Cost.)*	ELU:I
			Cost. (Endosiphonites)	ELU:I
			?Trochoclymenia	LU:I
			Mesoclymenia	ELU:I
		Sellaclymeniinae	*Sellaclymenia*	$(E_1E_1)LU:I$
	Biloclymeniidae	Pachyclymeniinae	*Uraloclymenia*	EL:I
			Pachyclymenia	EL:UI
		Biloclymeniinae	*Biloclymenia*	$(E_1E_2E_1)L:UI$
			Gen. Nov. *C*	$(E_1E_1)LU:UI$
	Wocklumeriidae		*Wocklumeria*	ELU:UUI
			Epiwocklumeria	ELU:UUI
PARAWOCKLUMERIACEAE	Parawocklumeriidae		*Kamptoclymenia*	$(E_1E_1)L:(I_1I_1)$
			Triaclymenia	L
			Parawocklumeria	$(E_1E_1)L:U(I_1I_1)$
GONIOCLYMENIACEAE	Gonioclymeniidae	Gonioclymeniinae	*Gonioclymenia (Gon.)*	EALU:I
			Gon. (Kalloclymenia)	EALU:I
			Gon. (Subgen. Nov. *A)*	EALU:I
			Gon. (Subgen. Nov. *B)*	EALU:I
		Sphenoclymeniinae	*Schizoclymenia*	$EALU:U_1I$
			Sphenoclymenia	$EA_2A_1LU:U_1I$

CLYMENIACEAE	Platyclymeniidae	Platyclymeniinae	*Platyclymenia (Plat)*	L:I
			Plat. (Pleuroclymenia)	L:I
			Plat. (Trigonoclymenia)	L:I
			Plat. (Spinoclymenia)	L:I
			?Stenoclymenia	EL:I
			?Trochoclymenia	LU:I
		Subfam. Nov. α	*Sulcoclymenia*	AL:I
			Piriclymenia	AL:I
			Ornatoclymenia	ALU:I
	Cyrtoclymeniidae		*Cyrtoclymenia*	L:I
			Protactoclymenia	L:I
	Rectoclymeniidae		Gen. Nov. *D*	L:I
			Gen. Nov. *E*	L:UI
			Cteroclymenia	LU:UI
	Carinoclymeniidae		Gen. Nov. *F*	EL:I
			Carinoclymenia	EL:I
			Pinacoclymenia	$ELU_1:UI$
	Clymeniidae		*Aktuboclymenia*	L:I
			Protoxyclymenia	AL:I
			Kosmoclymenia	AL:I
			Clymenia	L:I
	Cymaclymeniidae		*Genuclymenia*	AL:UI & AL:I
			Cymaclymenia	ALU:I
			Kazakhoclymenia	EAL:UI
			Laganoclymenia	EL:UI

Textfig. 4.4 Classification of the Order Clymeniida, divided into the Suborder Gonioclymeniina (above the line), and Suborder Clymeniina (below the line). Sutural formulae are based on Wedekind's system, after Wiedmann and Kullmann (1981). N.B. The sutural formulae of *Hexaclymenia* and *Progonioclymenia (Prog.)* have been transposed. *Riphaeoclymenia*, $(E_1E_1)LU:UI$, has been omitted from the Biloclymeniinae.



Clymeniida: generic range chart for the Famennian.

comprising ventral, lateral and dorsal lobes, to which may be added a ventral saddle and an umbilical lobe.

Glatziellidae

Two subfamilies are recognised: the earlier Hexaclymeniinae, with a simple suture comprising ventral, lateral and umbilical lobes, and the Glatziellinae, in which the ventral lobe becomes subdivided and there may also be an additional umbilical lobe (Textfig. 4.6).

Hexaclymeniinae

There are two genera, *Hexaclymenia* and *Progonioclymenia*. Both have the same sutural shape (Textfigs. 4.5J-L). *Hexa-clymenia* has a distinctive hexagonal shell form, and is known only from the *delphinus* Zone. *Progonioclymenia* is evolute and strongly ribbed. Two subgenera are recognised: *Prog*. (*Progonioclymenia*) which has a compressed whorl section, and is known from the *Clymenia* Stufe, and *Prog*. (*Soliclymenia*), known from the *annulata* Zone and the *Wocklumeria* Stufe, which has a depressed whorl section, and develops triangular coiling in one species.

Glatziellinae

Two genera are recognised: *Glatziella* and *Postglatziella* in which there is an additional umbilical lobe (Textfigs. 4.6F-H). Early species (*endogona* Subzone: stratigraphic data from Schindewolf 1937a) of *Glatziella* are evolute with strong ribs and shallow (*tricincta*), and deep (*helenae*) ventro-lateral grooves. *Glatziella tricincta* differs from *Prog*. (*Soli*.) *solarioides*, from which it probably evolved, by having a ventral saddle, rather than a lobe,

Textfig. 4.6

Parawocklumeriidae

A, B <u>Parawocklumeria paradoxa</u>; C, <u>Triaclymenia triangularis</u>;

D, E <u>Kamptoclymenia endogona</u>.

Glatziellinae

F, G, <u>Postglatziella carinata</u>; H, I, <u>Glatziella diensti</u>.

Hexaclymeniinae

J, <u>Progonioclymenia</u> ?<u>aegoceras</u>; K, <u>Soliclymenia solarioides</u>;

L, <u>Hexaclymenia hexagona</u>.

All after Schindewolf 1937a (figs. 6,7,17,19,20,22,23) except L, after Schindewolf 1972 (fig. 3). All magnifications are unstated.

Textfig. 4.7

Sellaclymeniaceae, Sellaclymeniidae

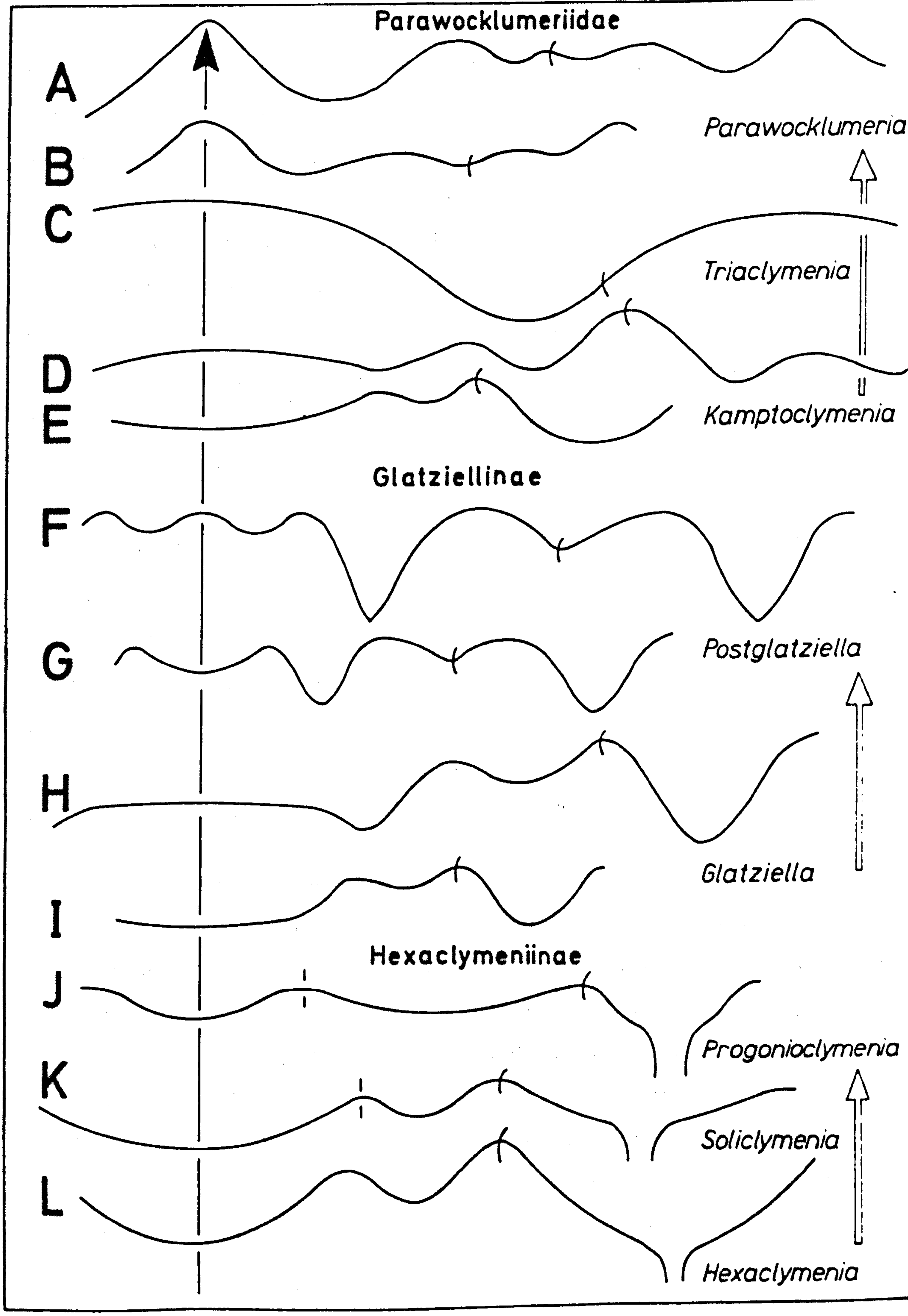
A, <u>Sellaclymenia angulosa</u>, D=30, WH=11, BSP AS VII 589.

Sellaclymeniaceae, Costaclymeniidae

B, <u>Mesoclymenia nalivkinae</u> (after Bogoslovskiy 1981, fig. 9): i, WW=8, WH=15.5; ii, WW=4, WH=7; C, <u>Costaclymenia multicostata</u>, (after Bogoslovskiy 1981, fig. 7), D=51, WW=10.4, WH=14;

D, <u>Cost</u>. <u>kiliani</u>, partial sutural ontogeny: i, WH=8.8, ii, WH=4.65, iii, WH=3.2.

Textfig. 4.6



Parawocklumeriidae
A
B
C
D
E
Parawocklumeria
Triaclymenia
Kamptoclymenia
Glatziellinae
F
G
H
I
Postglatziella
Glatziella
Hexaclymeniinae
J
K
L
Progonioclymenia
Soliclymenia
Hexaclymenia

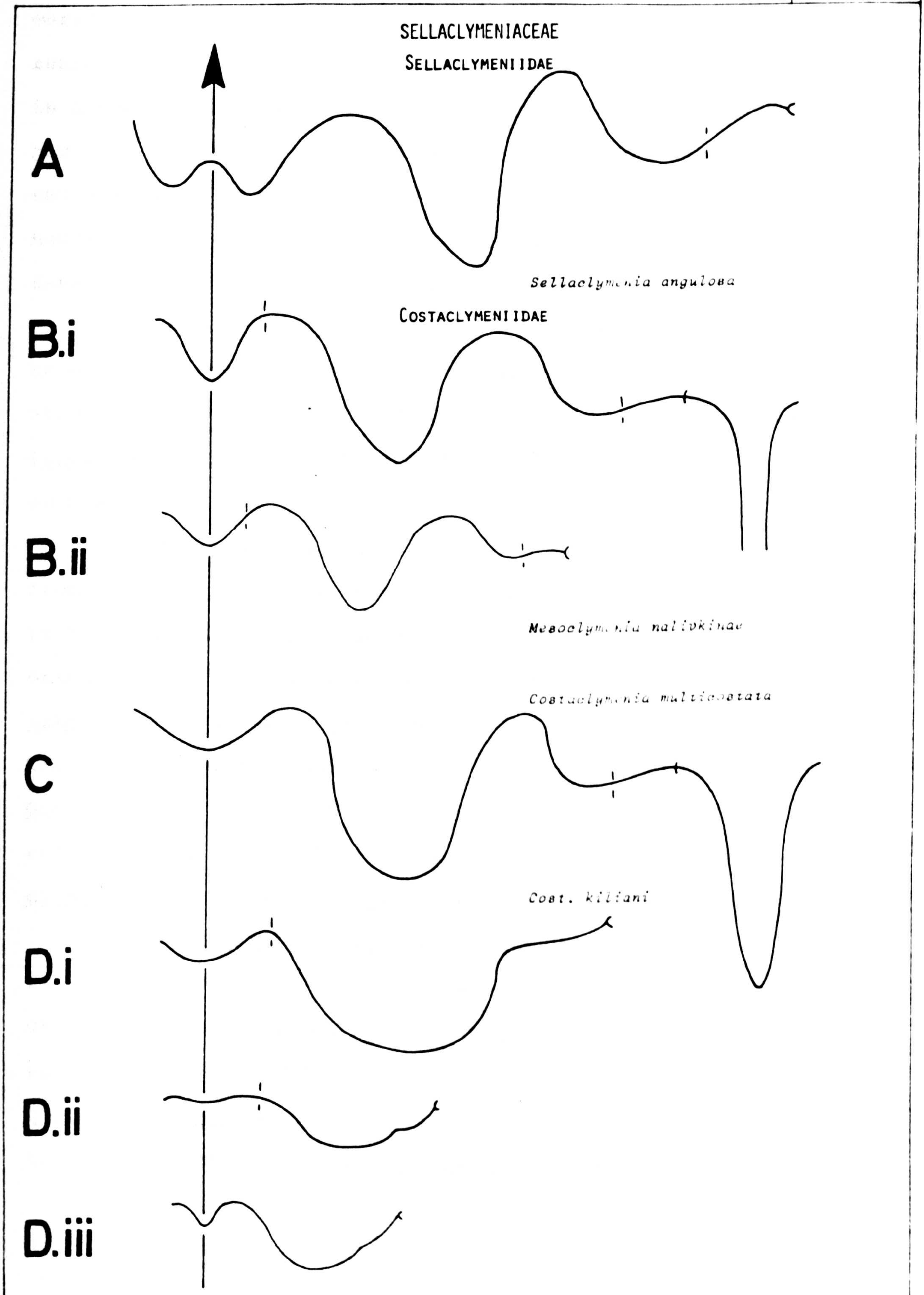
and ventro-lateral grooves. Later species (diensti, buxtorfi, pasquayi) develop more depressed whorl sections, resulting in a globular shell form. The last known species (glaucopis) loses its ribs and has a very depressed section (Weyer 1981). Sun and Shen (1965) erected a new subgenus (Sinoglatziella) for smooth forms such as this. Postglatziella, known from the sphaeroides Subzone, has weak ribs, a depressed whorl section and globose shell, a narrow umbilicus and an extra umbilical lobe.

Evolutionary trends within the Glatziellinae are a decrease in the degree of shell evolution, increased depression of the whorl section, increased globularity of the shell form, loss of strong ornament and deep ventro-lateral grooves (surely a function of the whorl width/whorl height ratio), and addition of an umbilical lobe. Within the Hexaclymeniinae the only trends would seem to be an increased depression of the whorl section (not wholly confirmed by stratigraphic data), and the development of triangular coiling.

Sellaclymeniidae

Two subfamilies are recognised: the Sellaclymeniinae and the Costaclymeniinae, the former having a presumed secondarily subdivided ventral lobe (Textfig. 4.7). Stratigraphical evidence for the evolution of this small group is lacking. Costaclymenia (Costaclymenia) multicosta (Textfig. 4.7C) is a small strongly ribbed species from the annulata Zone, with a compressed whorl section. Its direct ancestor is unknown. It is extremely different in shell form and growth-line course from Prog. (Soli.) solarioides, the only other representative of the Gonioclymeniina known from the annulata Zone. Investigation of the sutural ontogeny (Textfig. 4.7D) of a later species (kiliani) shows the

Textfig. 4.7


SELLACLYMENIACEAE
SELLACLYMENIIDAE
A
Sellaclymenia angulosa
COSTACLYMENIIDAE
B.i
B.ii
Mesoclymenia nalivkinae
Costaclymenia multicostata
C
Cost. kiliani
D.i
D.ii
D.iii

early suture to have a broad, deep lateral lobe and a ventral lobe, reminiscent of Stenoclymenia, one species of which (sandbergeri) is a near homeomorph of End. (Cost.) multicosta. (Stenoclymenia has a ventral lobe, which recent authors have considered as secondary, and thus have included it within the Clymeniina. Lange, however, considered it to be a gonioclymeniid. There are no details of sutural ontogeny of Stenoclymenia.)

Species of Endosiphonites from the Clymenia Stufe are divided here into subgenera by their ornament; End. (Costaclymenia) has strong ribs, or tubercles, but these are weak or absent in End. (Endosiphonites). Their relative stratigraphic positions are unknown.

Mesoclymenia (Textfig. 4.7B) is an interesting genus known from the Clymenia Stufe of Kazakhstan (Bogoslovskiy 1981). It has a smooth shell, with a ventral groove developed early in ontogeny, and a suture with the same number of elements as Endosiphonites, but with a pointed, rather than a broad, lateral lobe. Thus it represents a stage intermediate between Endosiphonites and Gonioclymenia, from which it differs only by the absence of a ventro-lateral (Adventive) lobe, and ribbing. Presumably Gonioclymenia evolved from Endosiphonites via Mesoclymenia.

Sellaclymenia (Textfig. 4.7A) is known from only few examples. It is believed to have evolved from Endosiphonites, by formation of a ventral saddle, rather than Mesoclymenia, since that genus has a smooth shell and a ventral groove. The earlier Sellaclymenia torleyi (Clymenia Stufe) has an ornament consisting of strong tubercles, whereas the later Sell. plana is smooth.

Biloclymeniidae

This family, as used here, differs in composition from the

Textfig. 4.8

Biloclymeniinae

A, Riphaeoclymenia canaliculata, (after Bogoslovskiy 1981, fig. 21), D=30, WW=9.0, WH=7.6; B, Gen. Nov. C, (after Schindewolf 1937a, fig. 10); C, Biloclymenia uralica, partial sutural ontogeny; i, WW=13.7, WH=13.6; ii, D=21.3, WW=9.1, WH=10.6; iii, WW=6.5, WH=6.5; iv, WW=4.5, (after Bogoslovskiy 1955); D, Biloclymenia semiplicata, WW=10.7, WH=9.8, (after Bogoslovskiy 1981, fig. 18).

Sellaclymeniaceae, Wocklumeriidae

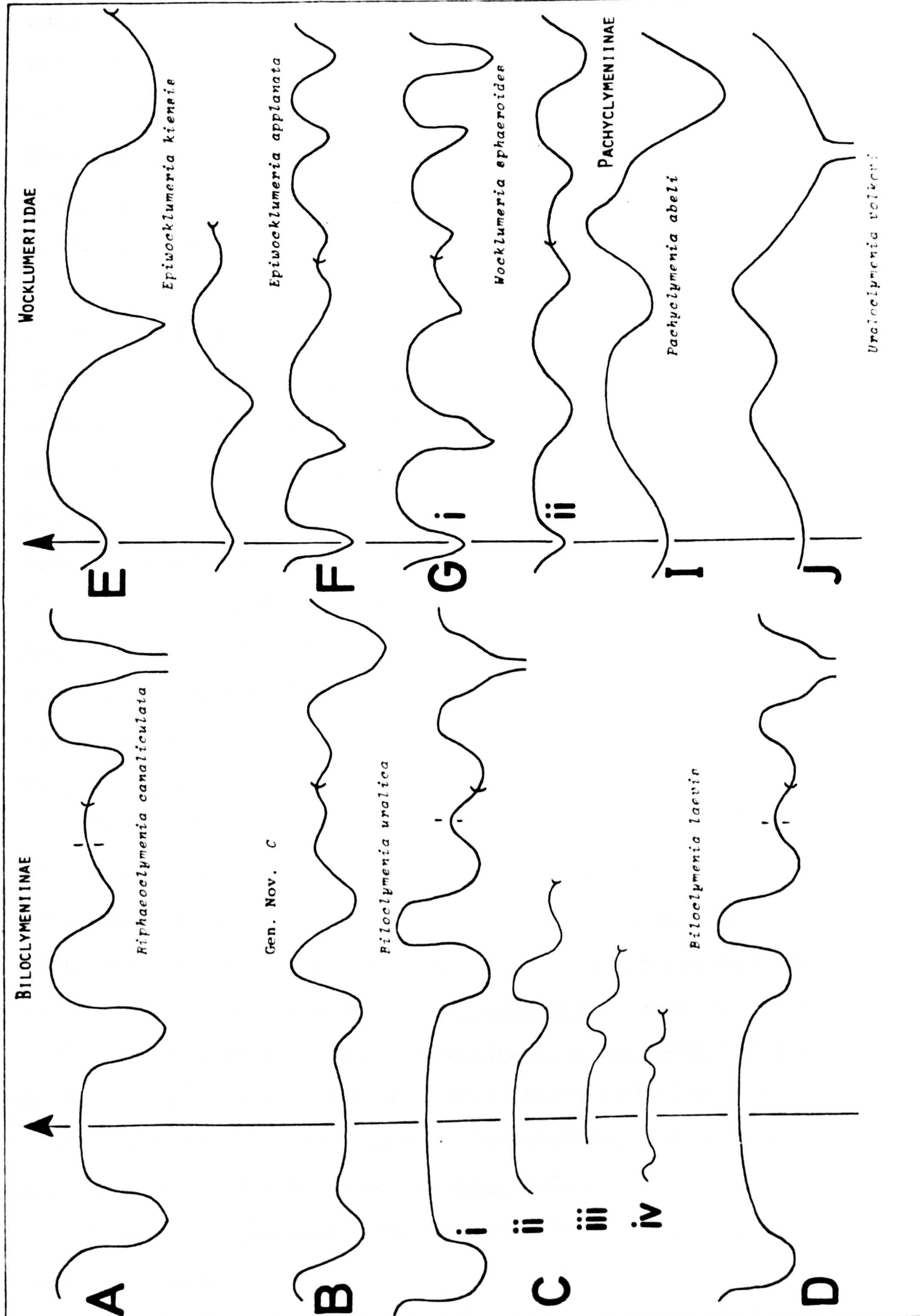
E, Epiwocklumeria kiensis, D=24, WW=13, WH=12 and WW=4.6, WH=5; F, Epiwocklumeria applanata, (after Schindewolf 1937a, fig. 13); G, Wocklumeria sphaeroides (after Schindewolf 1937a, fig. 12).

Sellaclymeniaceae, Biloclymeniidae, Pachyclymeniinae

I, Pachyclymenia abeli, (after Schindewolf 1937a, fig. 11); J, Uraloclymenia volkovi, D=18, WW=10, WH=6.7, (after Bogoslovskiy 1981, fig. 13).

Textfig. 4.9

A, Parawocklumeria paradoxa; B, Parawocklumeria distorta; C, Triaclymenia triangularis; D, Kamptoclymenia trivaricata; E, Kamptoclymenia trigona; F, Kamptoclymenia endogona. All after Schindewolf 1937a, figs. 20,25,26,27, (all magnifications unstated).


BILOCLYMENIINAE
WOCKLUMERIIDAE
PACHYCLYMENIINAE
A
Riphaeoclymenia canaliculata
B
Gen. Nov. C
Piloclymenia uralica
C
i
ii
iii
iv
D
Biloclymenia laevis
E
Epiwocklumeria kiensis
F
Epiwocklumeria applanata
G
i
ii
Wocklumeria sphaeroides
I
Pachyclymenia abeli
J
Uraloclymenia volkovi

usage of Bogoslovskiy (1955, 1981), principally because of a reappraisal of the genera which he recognised as valid. He used two families, Miroclymeniidae (Uraloclymenia, Pachyclymenia and Miroclymenia) and Biloclymeniidae (Kiaclymenia, Biloclymenia and Riphaeoclymenia), the distinction between them being drawn on subdivision of the ventral lobe (Textfig. 4.8A-D,I,J). Miroclymenia is not accepted as a valid genus, but is treated as a possible synonym of Cymaclymenia. Erected by Schindewolf (1923b) and diagnosed as like Cymaclymenia, but with a ventral lobe, it was used as the type-genus for the subfamily Miroclymeniinae Schindewolf 1924, containing Miroclymenia and Wocklumeria. Later (1937a) Schindewolf reported the apparent loss of the only specimen of Miroclymenia from the collections at Jena and described it as a juvenile, only 15mm in diameter. On these grounds he considered Miroclymenia to be a "genus inquirendum" and thus unreasonable for use as the type for a family, and so he erected a new family, Wocklumeridae, to replace it, comprising Pachyclymenia, Miroclymenia, Wocklumeria, Epiwocklumeria and Biloclymenia.

In 1955 Bogoslovskiy erected a new family Biloclymeniidae to accommodate Biloclymenia and Kiaclymenia, which differed from the above listed genera by having a subdivided ventral lobe. Ruzhencev (1957) further divided Schindewolf's Wocklumeriidae into three families, Miroclymeniidae (Miroclymenia, Pachyclymenia, EL:I or EL:UI) Wocklumeriidae (Wocklumeria, Epiwocklumeria and Synwocklumeria, with three umbilical lobes) and Biloclymeniidae (with subdivided ventral lobe). Bogoslovskiy (1960) described intermedia, a new species of Pachyclymenia, with an incipient umbilical lobe, apparently transitional between Pach. abeli and Miro. interpres.

Schindewolf (1972) accepted Bogoslovskiy's new evidence confirming a link between Pachyclymenia and Miroclymenia and reinstated the family Miroclymeniidae. He retained the Wocklumeriidae but treated the Biloclymeniinae as a subfamily of the Miroclymeniidae, regarding the subdivision of the ventral lobe to be worthy of recognition only at subfamilial level, as he had done for the Sellaclymeniinae.

Bogoslovskiy (1977) reiterated his argument when he established a new genus Uraloclymenia, intermediate in sutural form between Hexaclymenia and Pachyclymenia. He saw this new genus as the ancestor of Biloclymenia, and considered that Wocklumeria was derived from Pachyclymenia. I would agree with these phylogenetic conclusions.

Korn (1981a) erected nephroides, a new species of Cymaclymenia, which had a suture exactly like that of Miro. interpres, but later in ontogeny the ventral lobe transformed into a saddle. The shell form also agrees with Schindewolf's (1937a) description of interpres. On this evidence I would endorse Schindewolf's own statement (1923b) that Miro. interpres was like Cymaclymenia and suggest that it is a Cymaclymenia. Therefore Miroclymenia and Miroclymeniidae can be treated as synonyms of Cymaclymenia and Cymaclymeniidae, respectively.

It is argued below (Chapter 5) that the biloclymeniid group comprises only Biloclymenia, Gen. Nov. C and Riphaeoclymenia, and deserves only subfamilial rank, since it is characterised only by the subdivision of the ventral lobe. (Although Riphaeoclymenia, differing only by its shell form, may warrant only subgeneric status (cf. Kalloclymenia, Soliclymenia, Trigonoclymenia etc.)). A new subfamily, Pachyclymeniinae, is then required to accommodate Pachyclymenia and Uraloclymenia, and both of these subfamilies are placed in the Biloclymeniidae because Miroclymeniidae is accepted as a synonym of Cymaclymeniidae. Should Miroclymenia be shown to be a valid genus, with a true ventral lobe, then the family name would revert to Miroclymeniidae.

Wocklumeriidae

Two genera are included here, Wocklumeria and Epiwocklumeria (Textfig. 4.8E-G), distinguished only by their shell form. The later Epiwocklumeria is involute in contrast to Wocklumeria, which is subinvolute, becoming subevolute in later whorls. Both exhibit triangular coiling. There seems no way to distinguish Synwocklumeria (Librovich 1957, Bogoslovskiy 1981) from Epiwocklumeria (but see Chapter 5).

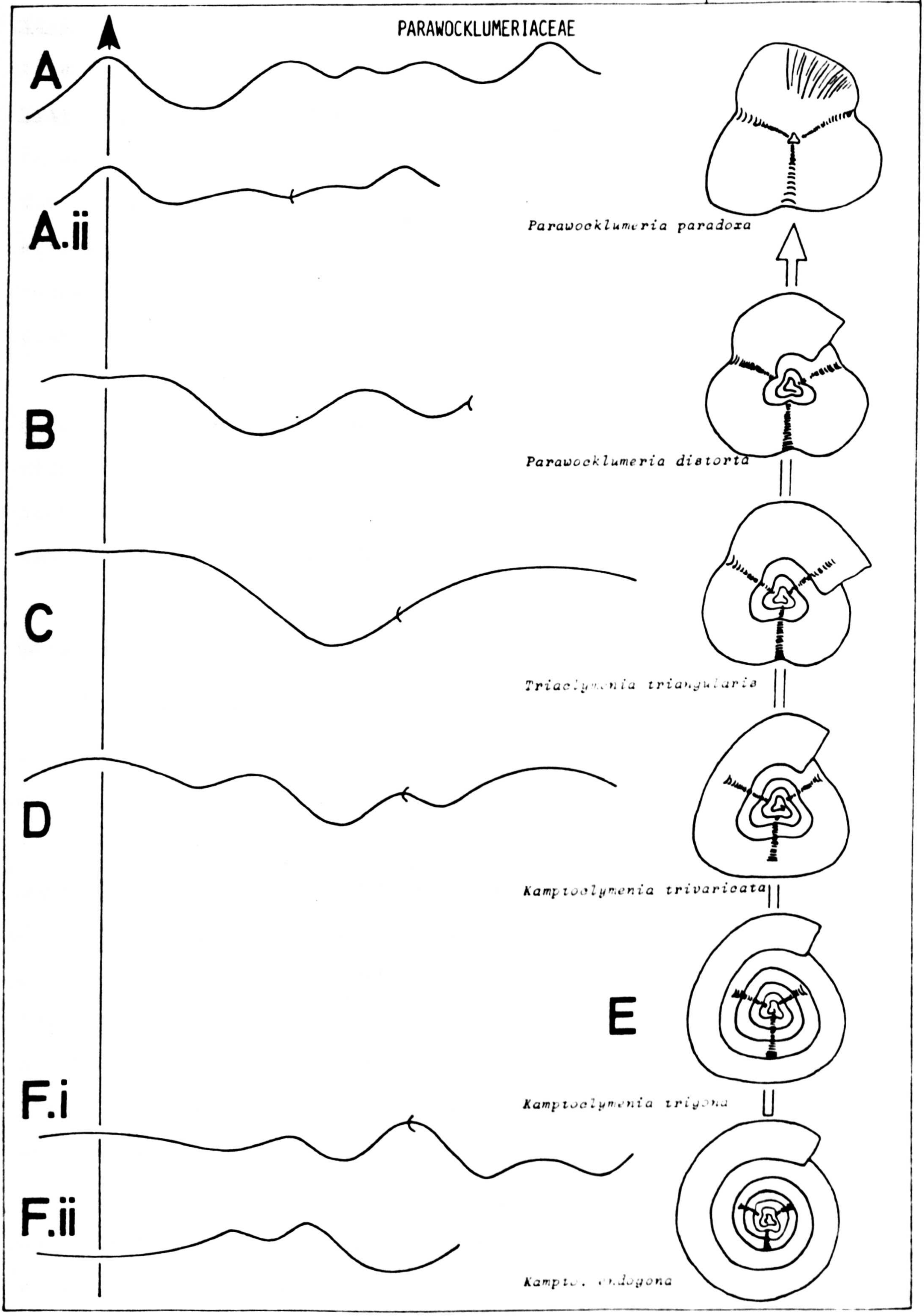
Parawocklumeriaceae

This superfamily has been included within the Platyclymenida (Schindewolf 1937a) or been treated as equal in rank to Gonioclymeniaceae and Clymeniaceae (Schindewolf 1957). Ruzhencev (1957) included them within the Gonioclymeniina. Weyer (1981) gave them only subfamilial rank within the Glatziellidae.

Only one family, Parawocklumeriidae, is recognised, united by the possession of divided ventral and dorsal lobes (i.e. it has ventral and dorsal saddles Textfig. 4.9). To it are assigned three genera, Kamptoclymenia, Triaclymenia and Parawocklumeria, which were the subject of a study by Schindewolf (1937a).

These three genera are separated somewhat arbitrarily by their degrees of involution: Kamptoclymenia, evolute; Triaclymenia, subevolute to subinvolute, and Parawocklumeria subinvolute to involute. Parawocklumeria also has an extra umbilical lobe. All three genera appear at the base of the endogona Subzone, in Bed 10 at Oberrödinghausen (Schindewolf 1937a). Schindewolf (1937a, textfig. 27) arranged all of the species of Kamptoclymenia,

Textfig. 4.9


PARAWOCKLUMERIACEAE
A
A.ii
B
C
D
E
F.i
F.ii
Parawocklumeria paradoxa
Parawocklumeria distorta
Triaclymenia triangularis
Kamptoclymenia trivaricata
Kamptoclymenia trigona
Kampto.

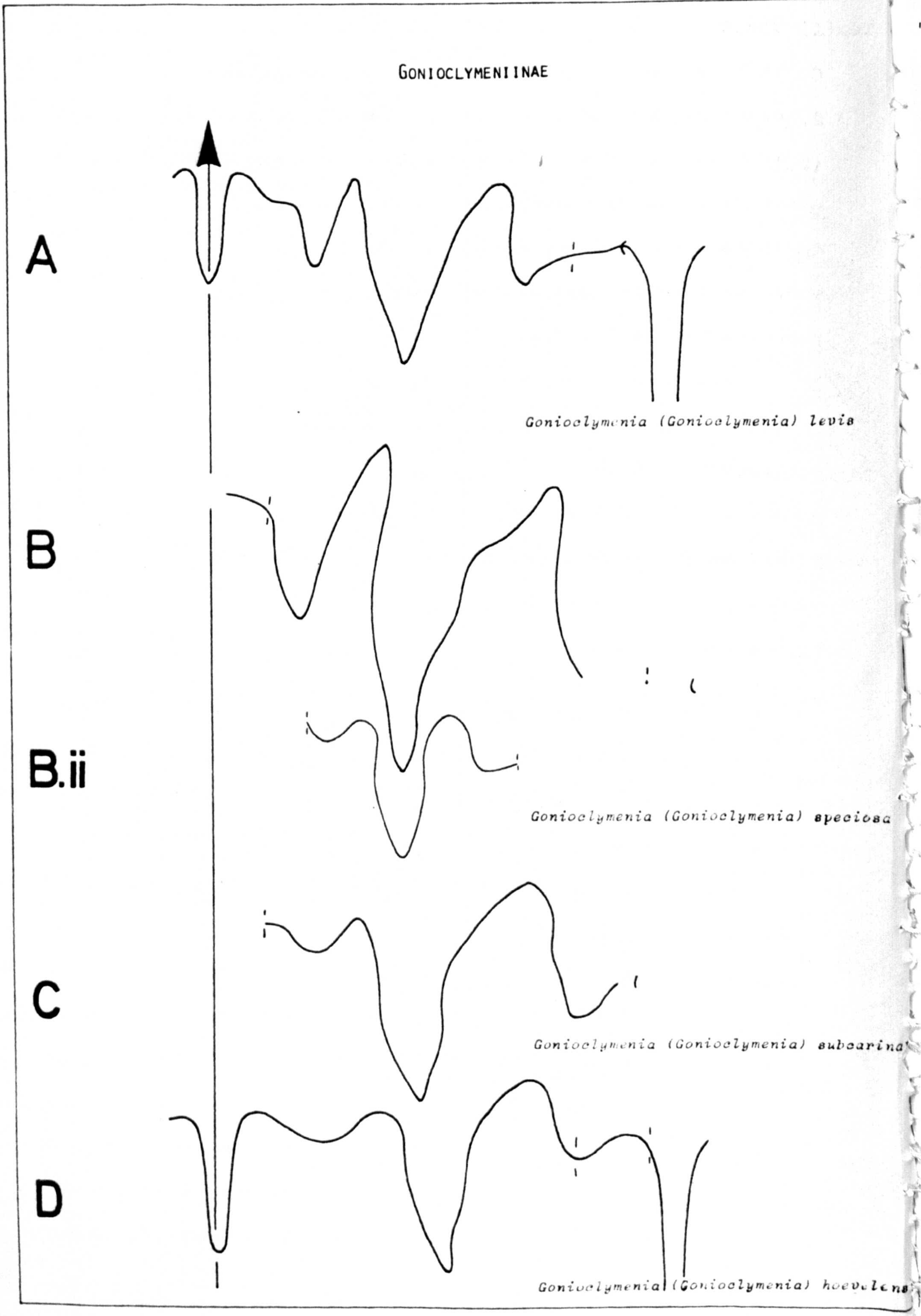
Triaclymenia and _Parawocklumeria_ in an evolutionary series from from _Kampto_. _endogona_ through _Kampto_. _trigona_, _Kampto_. _trivaricata_, _Tria_. _triangularis_, _Para_. _patens_, _Para_. _distorta_ to _Para_. _paradoxa_, in which there is increasing involution, and triangularity of the shell coiling, emphasised by deep constrictions. There is no stratigraphic basis for this series, since the ranges of all species (except _Para_. _paradoxa_) are either uncertain, or concurrent (Schindewolf 1937a).

The immediate ancestor of _Kampto_. _endogona_ is unknown. _Progonioclymenia_ (_Soli_.) _solarioides_ is morphologically most similar, but this has strong ribs, and lacks the ventro-lateral grooves and dorsal saddle present in _Kampto_. _endogona_, and is therefore unlikely to be its direct antecedent.

Gonioclymeniaceae

Two subfamilies are recognised, Gonioclymeniinae (_Gonioclymenia_, divided into subgenera) and Sphenoclymeniinae (_Sphenoclymenia_) distinguished by their sutural formulae, Sphenoclymeniinae having extra umbilical and ventro-lateral lobes (Textfig. 4.11). _Gonioclymenia_, which appears low in the _Clymenia_ Stufe, was probably derived from _Mesoclymenia_, by addition of a ventro-lateral lobe. Little stratigraphic evidence is available to give credence to any phylogenetic consideration of this group. Wedekind (1914) and Schmidt (1924) recognised a lower division of the _Clymenia_ Stufe in which _Gon_. (_Gon_.) _hoevelensis_ and _Gon_. (_Gon_.) _subcarinata_ were present. These have shallow ventro-lateral lobes, and strong tuberculose ornament. _Gon_. (_Gon_.) _speciosa_, from the upper _Clymenia_ Stufe has a deeper ventro-lateral lobe, and a more subdued ornament (Textfig. 4.10B-D).

It seems that there are at least 5 lines of descent within


GONIOCLYMENIINAE
A
Gonioclymenia (Gonioclymenia) levis
B
B.ii
Gonioclymenia (Gonioclymenia) speciosa
C
Gonioclymenia (Gonioclymenia) subcarina
D
Gonioclymenia (Gonioclymenia) hoevelens

Textfig. 4.10

Gonioclymeniinae

A, Gonioclymenia (Gonioclymenia) levis, D=70, WW=11.6, WH=21, (after Bogoslovskiy 1981, fig. 35); B, Gonioclymenia (Gonioclymenia) speciosa, D=91, and D ca20, BSP AS VII 538; C, Gonioclymenia (Gonioclymenia) subcarinata, D ca59, WW ca15, WH ca20, BSP AS VII 595; D, Gonioclymenia (Gonioclymenia) hoevelensis, D=45, WW=9.5, WH=14.3, (after Bogoslovskiy 1981, fig. 31).

Textfig. 4.11

Gonioclymeniidae, Sphenoclymeniinae

A, Sphenoclymenia maxima (after Schindewolf 1920); B, Sphenoclymenia intermedia, WW=20.9, WH=40, holotype, BSP AS VII 586, combined with SM H10397 (internal suture only); C, Schizoclymenia drevermanni (after Drevermann 1901, pl. XIII, fig. 10).

Gonioclymeniidae, Gonioclymeniinae

D, Gonioclymenia (Subgen. Nov. B) wocklumensis, D ca30, holotype, MfN; E, Gonioclymenia (Kalloclymenia) subarmata, D=98, BSP AS VII 537; F, Gonioclymenia (Kalloclymenia) crassa, D=37, lectotype, RE 551.734.5 A255.

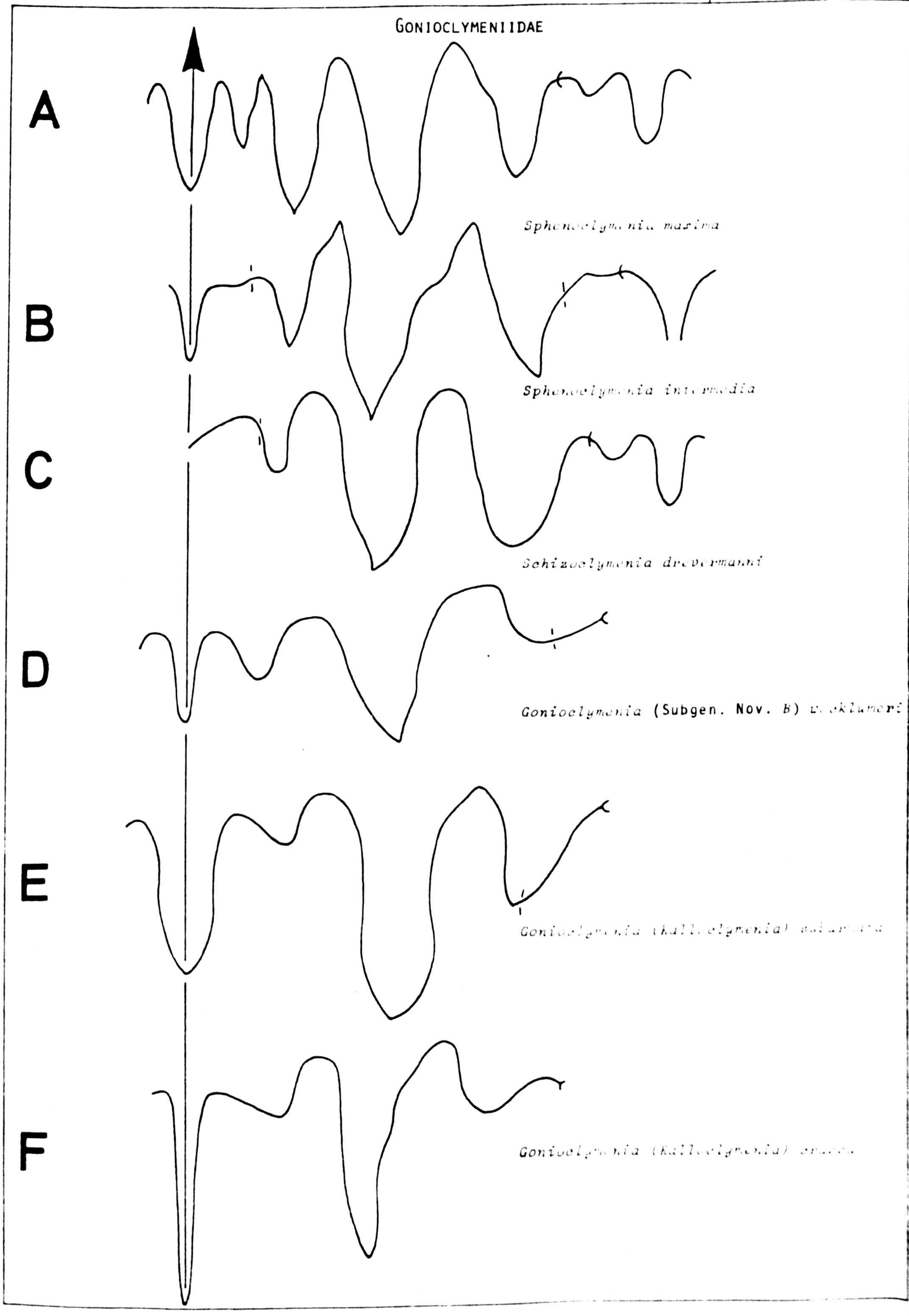
the Gonioclymeniaceae: Gonioclymenia (Kalloclymenia) with strong parabolic ribs, and a shallow ventro-lateral lobe appeared in the Clymenia Stufe (crassa Textfig. 4.11F); Gonioclymenia (Subgen. Nov. A), with a spinose ventro-lateral ornament and no ventro-lateral groove, appeared late in the Clymenia Stufe (brevispina); Gon. (Subgen. Nov. B) which lacks all ornament, occurs in the Wocklumeria Stufe; Gonioclymenia (Gonioclymenia) itself, retaining the ventral groove; and Sphenoclymenia with an extra umbilical and ventro-lateral lobe. Bogoslovskiy (1981) illustrated two species of Gonioclymenia (levis Textfig. 4.10A; kiensis) with incipient ventro-lateral lobes, which could be considered as intermediate to Sphenoclymenia. The little known Schizoclymenia can also be interpreted in the same light.

Some thirty gonioclymeniacean species have been erected by Münster, Wedekind (1914), Lange (1929), Petter (1960) and Bogoslovskiy (1981), and these can all be subdivided into plausible evolutionary lineages, but this will not be attempted for the want of stratigraphical details.

It can be noted, however, that somewhat later species of this genus demonstrate retention to the adult stage of characters, which in earlier species, are present only in early whorls. Thus Gon. (Kall.) subarmata has a tongue-shaped lateral lobe at larger diameters, resembling the early lateral lobe of Gon. (Gon.) speciosa (see Textfigs. 4.10Bii and 4.11E). The earlier Gon. (Kall.) crassa (Textfig. 4.11F) has a lateral lobe like the mature lateral lobe of Gon. (Gon.) speciosa.

Species of Gon. (Subgen. Nov. A) have a strong spinose ornament throughout all stages, and this ornament resembles that present only on the early whorls of Gon. (Gonioclymenia). A ventral groove is developed only in Gon. (Gonioclymenia). In other subgenera the flat venter of the earliest whorls is retained

Textfig. 4.11


GONIOCLYMENIIDAE
A
Sphenoclymenia maxima
B
Sphenoclymenia intermedia
C
Schizoclymenia drevermanni
D
Gonioclymenia (Subgen. Nov. B)
E
Gonioclymenia (Kalloclymenia)
F
Gonioclymenia (Kalloclymenia)

throughout growth.

Suborder Clymeniina

Only one superfamily, Clymeniaceae, is recognised within the Clymeniina, grouped together because all lose their ventral lobe early in ontogeny. There are six families: Platyclymeniidae, Cyrtoclymeniidae, Rectoclymeniidae, Carinoclymeniidae, Clymeniidae and Cymaclymeniidae. Division between them is in some cases rather arbitrary.

Platyclymeniidae

Two subfamilies are recognised, distinguished by their sutures: Platyclymeniinae and Subfam. Nov. α.

Platyclymeniinae

Platyclymenia is the major genus of this subfamily. It is evolute with a suture consisting of a ventral saddle, a broad lateral lobe and a dorsal lobe (Textfig. 4.12E). Growth-lines are concave over the flanks, and ribbing is common. Whorl section is circular to subcircular. At least sixty species have been assigned to this genus, most on the basis of just a handful of specimens. There are four subgenera, distinguished by their ornament (but see Chapter 5): Trigonoclymenia with parabolic ribs, Pleuroclymenia with a depressed whorl section, Spinoclymenia with a spinose ornament projecting ventrally from the ventro-lateral shoulder, and Platyclymenia itself (Textfig. 4.12).

Also included within the Platyclymeniinae are two rather problematic genera, Stenoclymenia and Trochoclymenia (Textfig. 4.12). Stenoclymenia contains forms which are indistinguishable from

Textfig. 4.12

Platyclymeniidae

A, Stenoclymenia stenomphala (after Lange 1929, fig. 12); B, Platyclymenia (Pleuroclymenia) crassissima, WW=11.8, WH=8, holotype, Mbg. 3154; C, Trochoclymenia wysogorskii (after Schindewolf 1937a, fig. 3); D, Trochoclymenia ornata, partial sutural ontogeny (after Petter 1960, fig. 2E); E, Platyclymenia (Platyclymenia) annulata (after Schindewolf 1934); F, G, H, diagnostic growth-lines of the subgenera Trigonoclymenia, Platyclymenia and Pleuroclymenia (all after Schindewolf 1934).

Textfig. 4.13

Clymeniidae

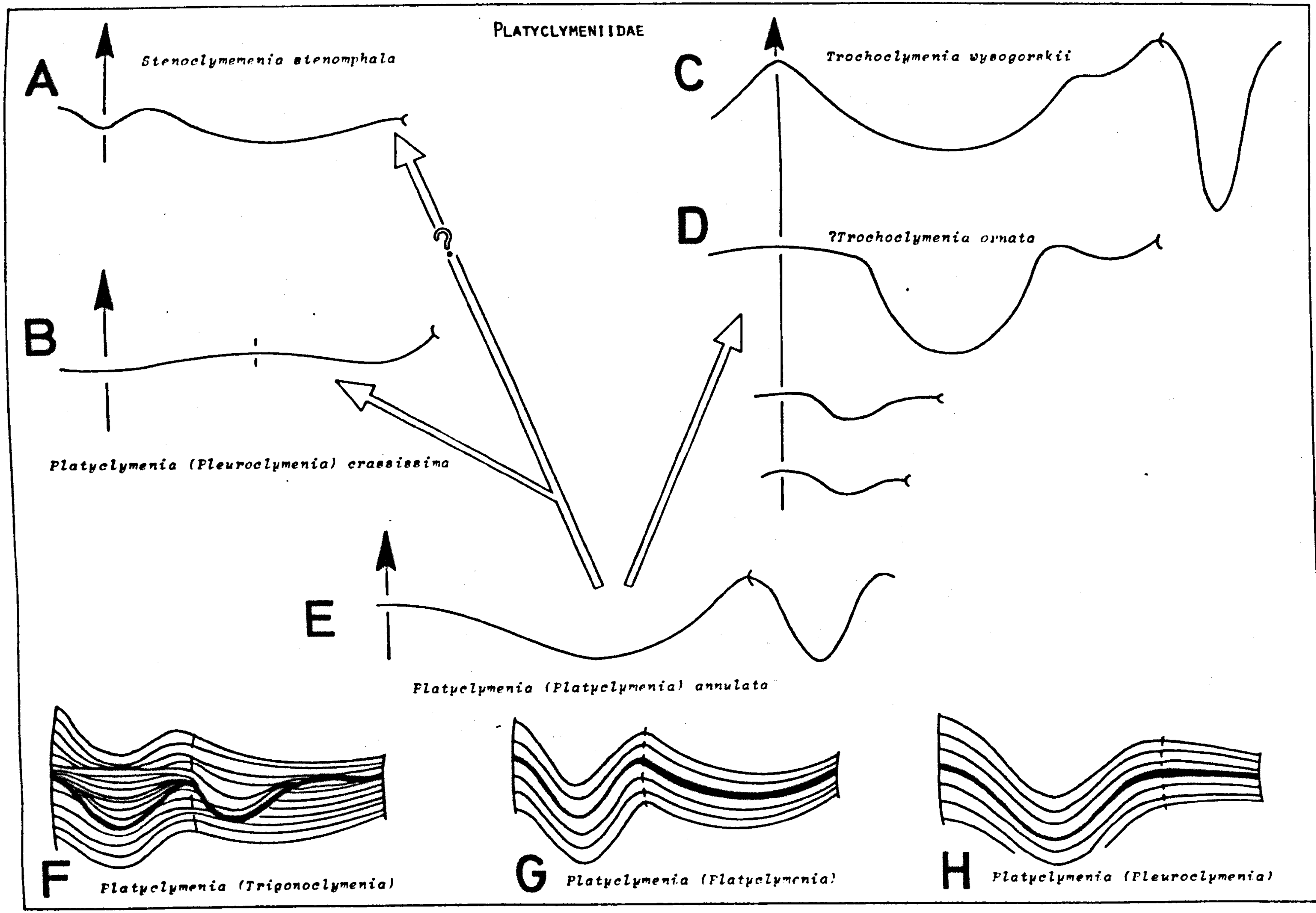
A, Kosmoclymenia sublaevis: i, WW=6.1, WH=5.9; ii, WW=3.3, WH=2.4; iii, WW=1.4, WH=1.9, DK 78D 1125.1; B, Clymenia laevigata, D=50, lectotype SM H10366. Internal suture after Schmidt 1924, fig. 4c; C, Protoxyclymenia dunkeri, WW=5.5, DK 81D 6430.2; D, Aktuboclymenia ancestralis, D=22.2, WW=6.7, WH=9 (after Bogoslovskiy 1979b, fig. 1).

Platyclymeniidae, Subfam. Nov.α

E, Piriclymenia piriformis (after Schindewolf 1937a, fig. 4);
F, Ornatoclymenia ornata, D=24, lectotype BSP AS VII 550;
G, Sulcoclymenia sulcata (after Schindewolf 1972, fig. 2b).

Platyclymeniidae, Platyclymeniinae

H, Platyclymenia (Platyclymenia) annulata (after Schindewolf 1934).


Platyclymeniidae
A
Stenoclymemenia stenomphala
B
Platyclymenia (Pleuroclymenia) crassissima
C
Trochoclymenia wysogorskii
D
?Trochoclymenia ornata
E
Platyclymenia (Platyclymenia) annulata
F
Platyclymenia (Trigonoclymenia)
G
Platyclymenia (Platyclymenia)
H
Platyclymenia (Pleuroclymenia)

Textfig. 4.12

Platyclymenia, except that they have a shallow ventral lobe (Textfig. 4.12A), considered by most authors to appear secondarily in ontogeny (reference has already been made to this under Costaclymeniidae above). Trochoclymenia is based on a single specimen from Dzikowiec (Ebersdorf) and was diagramatically illustrated by Schindewolf (1937a, Troch. wysogorskii, figs. 1,3). Recorded as being from Wrocław it is now presumed to have been lost when the collections were destroyed in the last war. It differs from Platyclymenia by having a small additional lobe near the umbilical seam (Textfig. 4.12C). Petter (1960, p. 34) erected Trochoclymenia ornata, which includes examples with a shell form and suture similar to Costaclymenia, except they have a flat ventral saddle up to a diameter of ca 25mm. The holotype of Troch. ornata (pl. III, figs. 8-8a) may be a true Costaclymenia, since it is a fragment of an outer whorl, and has a shallow ventral lobe. It is indistinguishable from End. (Endosiphonites) muensteri. The other specimens illustrated by Petter are all small (D<25), and have a very shallow lateral lobe with a flexure near to the umbilical seam, but do not actually form an umbilical lobe (Textfig. 4.12D). Therefore they are very similar to Platyclymenia, and may represent juveniles of Troch. wysogorskii. It is very easy to argue that a relationship exists between these specimens and Platyclymenia.

The distinction between some members of Platyclymenia, Cyrtoclymenia and Protactoclymenia is not always clear, especially for examples with a broad whorl section, subevolute coiling and prorsiradiate growth-lines (see Chapter 5). It is likely that there is some phylogenetic relationship between Cyrtoclymenia and Platyclymenia, at least, so this ambiguity will remain.

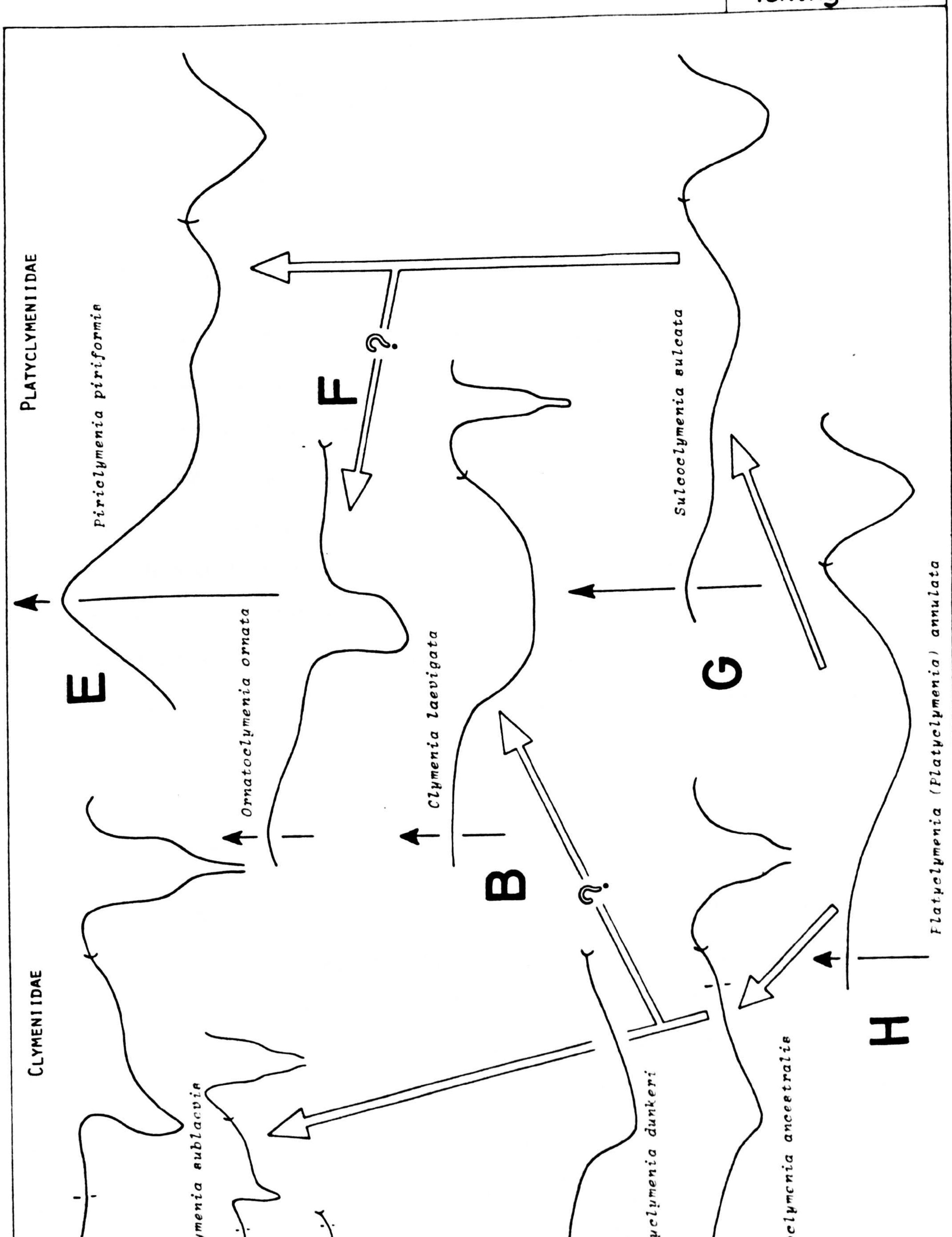
Subfam. Nov. α

This subfamily, for which the name Piriclymeniinae would be proposed, contains the genera Sulcoclymenia, Piriclymenia and Ornatoclymenia, which all have a similar pear-shaped whorl section. Their relationship and sutural development was described by Korn (1981a), who elaborated on the arguments of Schindewolf (1972), who derived this group from Platyclymenia by the formation of an adventive lobe (Textfig. 4.13E-G).

Korn (1981a) argued that Ornatoclymenia had a greater affinity with Sulcoclymenia than with the Cymaclymeniidae (contra Schindewolf 1957, Bogoslovskiy 1979b). His argument for this was that Ornatoclymenia had a V-shaped dorsal lobe, rather than a tongue-shaped dorsal lobe like Cymaclymenia, the umbilical and lateral lobes were rounded rather than pointed as in Cymaclymenia, and the adventive lobe was deep rather than shallow.

Which family these three genera are to be included within is largely determined by what is considered as their immediate ancestor. Schindewolf (1972) suggested that Sulcoclymenia and Piriclymenia were derived from Platyclymenia. Korn (1981a) suggested that Ornatoclymenia too was derived from Sulcoclymenia. Both Schindewolf (1957, 1972) and Bogoslovskiy (1981) include Piriclymenia and Sulcoclymenia in the Platyclymeniidae. Korn, however, placed them in the Clymeniidae, together with Aktuboclymenia, Protoxyclymenia, Kosmoclymenia and Clymenia. Bogoslovskiy's classification scheme allows the lineages Aktuboclymenia-Protoxyclymenia-Kosmoclymenia and Sulcoclymenia-Piriclymenia to be derived independently from Platyclymenia (see Textfigs. 4.13E-H). Korn's scheme requires Sulcoclymenia and Aktuboclymenia to be closely related, with one ancestral to the other, and derived from Platyclymenia through only one lineage. This idea was not discussed or sub-

Textfig. 4.13


CLYMENIIDAE
PLATYCLYMENIIDAE
i
ii
iii
A
Kosmoclymenia sublaevis
B
Clymenia laevigata
C
Protoxyclymenia dunkeri
D
Aktuboclymenia ancestralis
E
Ornatoclymenia ornata
F
Piriclymenia piriformis
G
Sulcoclymenia sulcata
H
Platyclymenia (Platyclymenia) annulata
?
?

stantiated by him in any way. Although the growth-lines, suture and shell form of Aktuboclymenia and Sulcoclymenia are quite similar a conservative approach is adopted here, and the two genera placed in separate families.

Cyrtoclymeniidae

This family contains only two genera, Cyrtoclymenia and Protactoclymenia, with a simple suture (Textfig. 4.15D) and are differentiated by the degree of involution, more evolute examples being included in the latter genus (see Chapter 5). Representatives of this family are quite rare, with the exception of Cyrt. involuta, which is the most common clymeniid in the delphinus Zone. Insufficient is known of the stratigraphic occurrence of this family to make any comments on its evolution, even though species included within Cyrtoclymenia range from the delphinus to paradoxa Zones.

Rectoclymeniidae

This family contains three genera, Gen. Nov. D (Rectoclymenia auctt.), Gen. Nov. E (Falciclymenia auctt.) and Cteroclymenia. Most species have a compressed carinate whorl section, and all have biconvex, radial growth-lines. The genera are distinguished by the number of umbilical lobes; Gen. Nov. D has none, Gen. Nov. E one, and Cteroclymenia two (Textfigs. 4.14A-C). Stratigraphic data for this group is rather poor; Gen. Nov. D is known from the delphinus Zone, and Gen. Nov. E from the annulata Zone, and possibly a little above (Brügge 1973). On this evidence, and their morphological similarity (apart from the number of umbilical lobes) they have been arranged in an evolutionary sequence,

Textfig. 4.14

Rectoclymeniidae

A, Cteroclymenia rozmanae, D=19.4, WW=7.2, WH=9.8 (after Bogoslovskiy 1979a, fig. 2a); B, Gen. Nov. E sp. a, WW=10.9 WH=23, Mbg; C, ?Gen. Nov. D finitima (after Bogoslovskiy 1975, fig. 1c).

Carinoclymeniidae

D, Pinacoclymenia inexpectata, WW=10.4, WH=30.5 (after Bogoslovskiy 1975, fig. 3b); E, Carinoclymenia thaumasta, WW=2.1 WH=5.7, (after Bogoslovskiy 1975, fig. 2b); F, Carinoclymenia beuelensis, D=25.2, WW=4.8, WH=12.4, (after Bogoslovskiy 1975, fig. 1d); G, Gen. Nov. F stuckenbergi (after Perna 1914, fig. 65).

Textfig. 4.15

Cymaclymeniidae

A, Cymaclymenia sp. b, D=32.8, WW=11, WH=17, SM H10406;

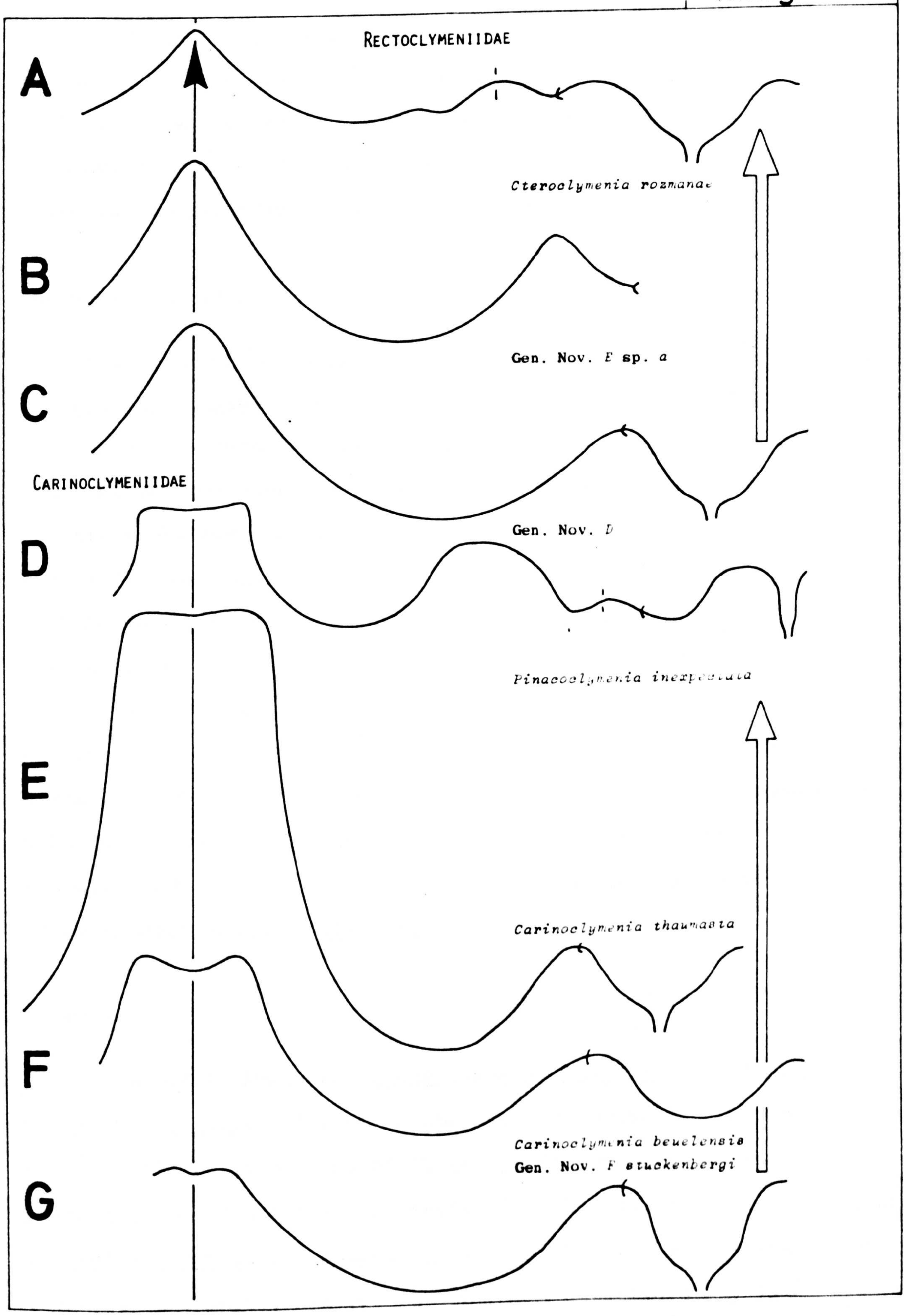
B, Genuclymenia karpinskii, WW=5.6, WH=7.5, DK 80D 4511.1;

C, Genuclymenia angelini (after Perna 1914, fig. 81).

Cyrtoclymeniidae

D, Cyrtoclymenia involuta, (after Schmidt 1924, fig. 4).

Textfig. 4.14


RECTOCLYMENIIDAE
A
Cteroclymenia rozmanae
B
Gen. Nov. E sp. a
C
CARINOCLYMENIIDAE
Gen. Nov. D
D
Pinacoclymenia inexpectata
E
Carinoclymenia thaumasta
F
Carinoclymenia beuelensis
Gen. Nov. F stuckenbergi
G

Rectoclymenia-Falciclymenia-Cteroclymenia (Bogoslovskiy 1979a). It has been argued (Lange 1929) that Gen. Nov. D kayseri is the earliest known clymeniid, being recorded from the sandbergeri Zone at Enkeberg (Lange 1929) and Kirch-Gattendorf (Schindewolf 1923b). These dates are, however, not beyond question (see Chapter 5).

Carinoclymeniidae

This family, containing the genera Gen. Nov. F, Carinoclymenia and Pinacoclymenia, is similar in many respects to the Rectoclymeniidae, except that growth-lines are prorsiradiate, biconvex, with the ventro-lateral salient being prominent. There is frequently a shallow ventral lobe (Textfig. 4.14D-G). Bogoslovskiy (1975) erected Acriclymenia, differentiated from Carinoclymenia by "the more prominently segregated carination of the shell emphasised by longitudinal grooves, by the broad ladle-shaped ventral sinus of the growth-lines and the unusually high ventral saddle of the suture" (Textfig. 4.14E). Such a finely drawn distinction does not warrant generic status (at least in comparison with the diagnoses of other Famennian clymeniid genera). Species assigned to Gen. Nov. F have previously been included within Rectoclymenia and Cyrtoclymenia.

Clymeniidae

This family includes Aktuboclymenia, Clymenia, Protoxyclymenia and Kosmoclymenia. The development of arguments surrounding the phylogenetic relationships of Clymenia, Protoxyclymenia and Kosmoclymenia is detailed in Chapter 5. The taxonomy and evolution of Protoxyclymenia and Kosmoclymenia, which will be separated into their own subfamily, are the subject of a detailed study in preparation by the author and a German colleague. Precise stratigraphic details were not available for inclusion in this thesis to justify the evolutionary scheme which will be proposed, but an outline is given here.

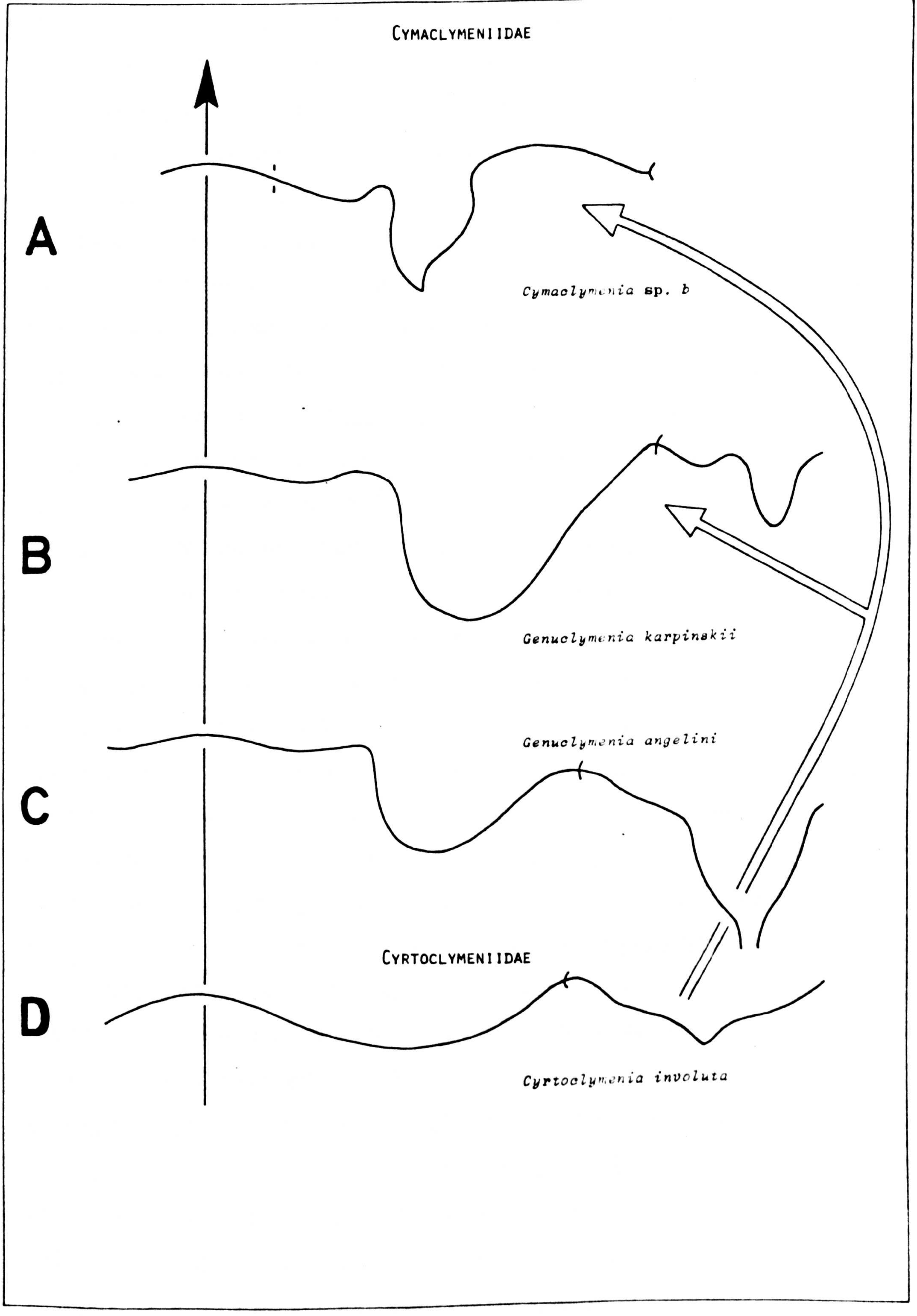
Kosmoclymenia is derived from *Protoxyclymenia* by the sharpening of the lateral lobe early in the *Clymenia* Stufe. Three lineages (indicated on Textfig. 4.5 as Gen. Nov. *J-L*) have been traced within *Kosmoclymenia*. In one (*Kosmoclymenia* s.s.) growth-lines become finer, more closely spaced, and change direction from prorsiradiate to rursiradiate simultaneously becoming more strongly biconvex, shell coiling becomes more evolute, the appearance of the first growth-lirae becomes delayed, and the ventral ornament changes from continuous flares to close but isolated spines, becoming increasingly more widely spaced until, in the species *wocklumeri*, they disappear altogether (Gen. Nov. *L*). In a second lineage (Gen. Nov. *J*) the ventral ornament is lost, and finer, more strongly biconvex, growth-lines developed, which change direction from radial to rursiradiate, and in a third lineage (Gen. Nov. *K*) ventral ornament is lost and deep ventro-lateral grooves are developed.

It is considered that *Protoxyclymenia* arose via *Aktuboclymenia* from *Platyclymenia* (*Plat.*) *quenstedti*, in the *annulata* Zone (Textfigs. 4.13A,C). *Clymenia* itself has a suture similar to *Aktuboclymenia* and *Protoxyclymenia* (Textfigs. 4.13B-D). A small evolute species of *Clymenia* is now known from the *annulata* Zone (Chapter 7) and so it may also be derived from *Aktuboclymenia*.

Cymaclymeniidae

The genera *Genuclymenia*, *Cymaclymenia*, *Lagonoclymenia* and *Kazakhoclymenia* are included here. *Genuclymenia* may be derived

Textfig. 4.15


CYMACLYMENIIDAE
A
Cymaclymenia sp. b
B
Genuclymenia karpinskii
Genuclymenia angelini
C
CYRTOCLYMENIIDAE
D
Cyrtoclymenia involuta

from *Aktuboclymenia* (Bogoslovskiy 1979b) but its shell form, growth-line shape and suture seem much closer to *Protactoclymenia* and *Cyrtoclymenia*. The relationship between *Cymaclymenia* and *Genuclymenia* has long been recognised (Schindewolf 1923b), the former being derived from the latter by the deepening and sharpening of the lateral lobe (Textfigs. 4.15A,B,D). This divergence must have taken place from a species which lacked the extra internal Umbilical lobe present in some (Textfig. 4.15B), presumably later, species of *Genuclymenia* (see Chapter 5). It should, however, be pointed out that the suture of *Cymaclymenia* passes through an ontogenetic stage which is similar to the mature suture of *Sulcoclymenia* (see Textfigs. 4.13G and 4.16Diii), which could be proposed as an ancestor. Wedekind (1908, 1914) considered that *Cymaclymenia* appeared in the *delphinus* Zone, but this contention has not been substantiated by any subsequent studies. If the origins of *Cymaclymenia* are as suggested above it should have appeared by the *annulata* Zone, which is the highest level from which *Genuclymenia* has been recorded. However, there are no reports of *Cymaclymenia* from what are frequently very rich *annulata* Zone faunas. Generally these are dominated by species of *Platyclymenia*, and species of *Genuclymenia* itself are rare, so perhaps there was some facies control over the distribution of early *Cymaclymenia*.

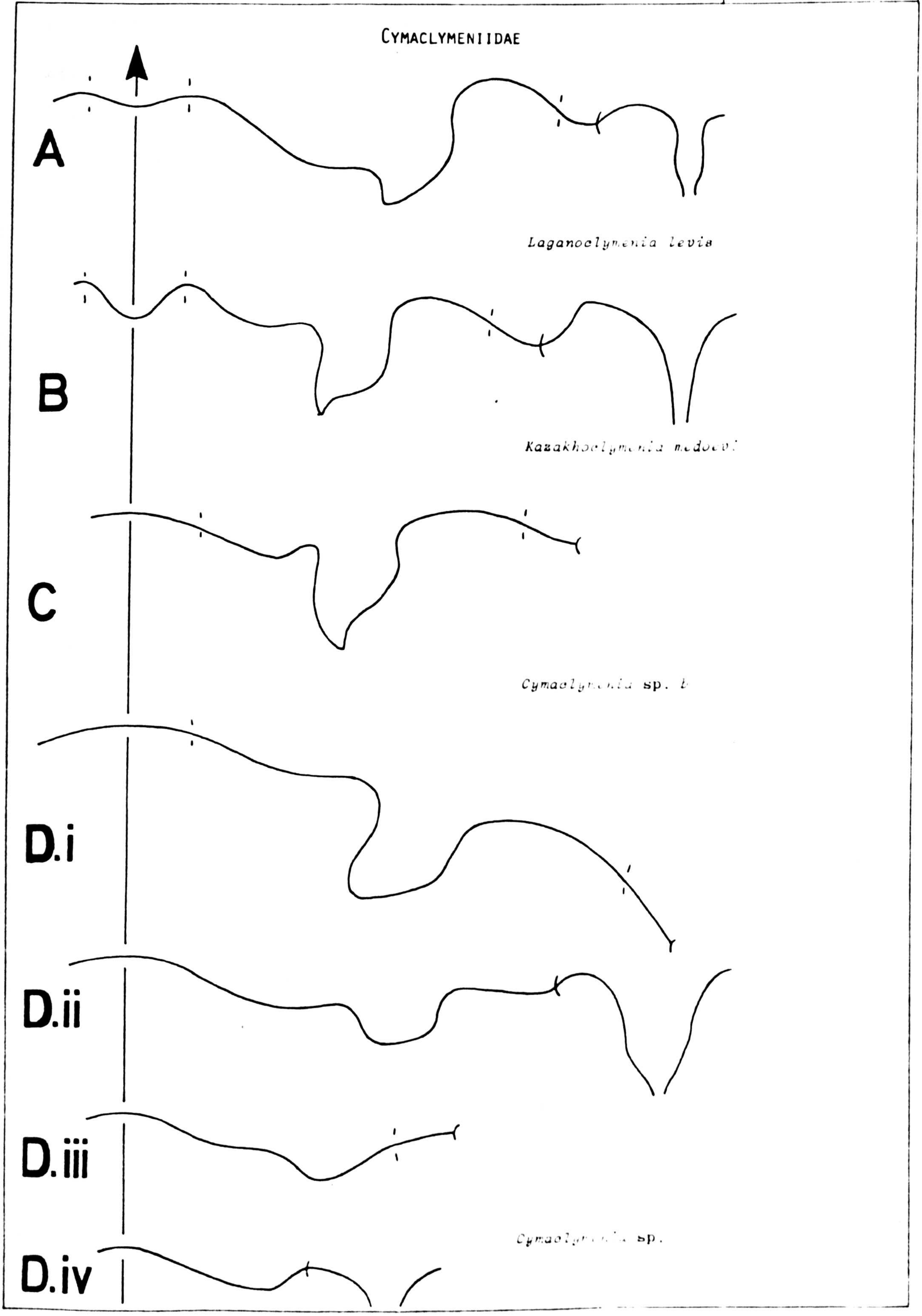
Kazakhoclymenia and *Laganoclymenia* were erected by Bogoslovskiy (1979b) to contain five specimens in which there was a shallow ventral lobe (Textfigs. 4.16A,B). The single known specimen of *Kazakhoclymenia*, from the *Clymenia* Stufe of Kazakhstan, differs from *Laganoclymenia*, known from the *Wocklumeria* Stufe of the southern Urals, by having a deep, more acutely pointed lateral lobe. *Cymaclymenia*, certainly a very successful genus in the *Clymenia* and *Wocklumeria* Stufen and is exceeded in frequency only

Textfig. 4.16

Cymaclymeniidae

A, _Laganoclymenia levis_, D=19.3, WW=4.1, WH=7.3 (after Bogoslovskiy 1979b, fig. 4); B, _Kazakhoclymenia medocvi_, D=36, WW=7.6, WH=13 (after Bogoslovskiy 1979b, fig. 3); C, _Cymaclymenia_ sp. _b_, D=32.8, WW=11, WH=17,SM H10406; D, _Cymaclymenia_ sp. i, WW=8, WH=11.5, HU P82. 19; ii, WW=1.44, WH=1.88; iii, WW=0.77, WH=0.76; iv, eighth septum, WW=0.43, WH=0.38, (ii-iv, HU P82. 18).

Textfig. 4.16



by _Clymenia laevigata_, _Parawocklumeria paradoxa_ and some species of _Kosmoclymenia_. _Cymaclymenia evoluta_ is believed to have been the last clymeniid to survive in the uppermost Devonian seas.

Chapter 5

Systematic descriptions; principally of the species originally described by Count Münster

Introduction

It is 150 years since Georg, Graf von Münster (see portrait, frontispiece) first reported ammonoids from the Fichtelgebirge, north eastern Bavaria (Münster 1831). In the following year he published a description of about 40 species, some of which were at first placed in the genus Planulites (Münster 1832), but were later placed in the new genus Clymenia (Münster 1834a). These are now recognised as representatives of the Order Clymeniida, which is confined to the upper Famennian, the uppermost part of the Devonian. This extremely diverse group of cephalopods evolved rapidly and is characterised by possessing a dorsal siphuncle, setting it apart from most other ammonoids.

In his time Münster had one of the largest palaeontological collections in Europe and in 1840 Adam Sedgwick purchased from him a duplicate series of specimens (Clarke and Hughes 1890). This is now in the Sedgwick Museum Cambridge and consists of some 10 000 specimens, many of which still bear Münster's handwritten labels. Münster provided a catalogue with this collection. A copy of the relevant pages is reproduced in Textfig. 8.1, together with photographs of typical labels (Textfig. 8.2). On Münster's death in 1847 the majority of his remaining collection passed to the Bavarian State Collections in Munich (now the Bayerische Staatssammlung für Paläontologie und historische Geologie), and the rest is now dispersed between the Museum für Naturkunde, Berlin; Universität Erlangen - Nürnberg; Bayreuth Museum and the British Museum (Natural History).

Most of the specimens which are discussed here derive from Famennian limestones in the area surrounding Hof, Oberfranken. Münster was fortunate in having as the source for these specimens, and many thousands more, the limestone crushing plant at St.

Georges Prison, Hof. Here were processed limestones extracted from quarries which included Elbersreuth, Schübelhammer, Geuser, Horwagen (near Naila) and Gattendorf.

The species which Münster established (Münster 1832, 1834b, 1839, 1840, 1842: see Chapter 8 for a review of his publications) have been revised by many authors but none of them has examined all the available material. Gümbel (1862, 1863) and Schindewolf (1923a,b) looked only at the specimens in Berlin and Munich, which has resulted in some misinterpretation. Although most of Münster's originals were saved from damage in Munich during the last war, the associated material was lost and the same fate befell material in Berlin. Consequently significance can now be attached to the Münster Collection in the Sedgwick Museum, Cambridge, because it is a well documented, rich source of primary material. Examination of this collection, together with the various other Münster Collections, has enabled a fuller reconsideration of Münster's species descriptions to be made, than by previous authors.

Famennian ammonoid taxonomic work relies heavily on the many species established by Münster and has always (with the single exception of Schindewolf 1923a) been conducted outside the area from which these species were first described. Any attempt to restudy Famennian ammonoid faunas must have as its basis a thorough documentation of the species described in the early 19th century literature, and especially those studied by Münster. This chapter attempts to go some way towards this goal and considers the clymeniids established by Münster. Some species are omitted because there is no suitable material available to redescribe them, but collecting from Oberfranken to fill this gap in our knowledge is now in progress. Species established by other authors are discussed where this is relevant.

The systematic classification (see Chapter 4) used here is based on that developed by Ruzhencev (1957, 1960, 1962) and Bogoslovskiy (1979b, 1981) and Weyer (1981), which is more comprehensive than that of Schindewolf (1957). Any useful modification of it must be based on evidence from ontogenetic studies of well preserved material, which is not available at present.

Abbreviations used throughout were referred to in Chapter 1, and relevant localities are described later in Chapter 7. Comments on the evolution of the Clymeniida are to be found in Chapter 4 and zonal names are discussed in Chapter 3. Data used in plotting the various graphs in this chapter will be found at the end.

Systematic Descriptions

Superorder Ammonoidea Zittel 1884

Order Clymeniida Wedekind 1914

Diagnosis: Ammonoidea with siphuncle situated at the dorsal margin. Septal necks retrochoanitic.

Description: Shell coiling is spiral or triangular, evolute to involute, serpenticonic to globose. Maximum size of adults ranges from 10-250mm. Whorl section is quadrate, circular, reniform, oval or subtriangular. Growth-lines are prorsiradiate, rectiradiate or rursiradiate, concave, concavo-convex or biconvex, with a ventral sinus. Ornament is either lacking, or there are weak or strong ribs, especially near the umbilicus, tubercles at the lateral shoulders, parabolic tubercles, ventral spines and flares running around the ventro-lateral shoulder.

The sutures are simple, lobes and saddles being rounded or pointed. In its simplest form the mature suture has a ventral, lateral and dorsal lobe, but can be more complicated by the addition of ventral saddles, adventitious and umbilical lobes or saddles. In sagittal section septa appear concave, or more rarely convex (adorally).

The protoconch is elliptical, or spherical, with a diameter measured at the nepionic constriction, of 0.8-1.1mm. The prosuture is latisellate (Branco 1880; Textfig. 4.2a) and in this the siphuncle is situated ventrally, migrating to the dorsum in the first and second sutures (Textfig. 4.2b; Bogoslovskiy 1976).

Two suborders, Gonioclymeniina and Clymeniina are recognised. In the former the primary ventral lobe persists throughout ontogenetic development, but in the Clymeniina it is replaced by a broad saddle. Some 60 or more genera are distinguished at present (Textfigs. 4.4, 4.5). Asioclymenia Sun and Shen 1965 was stated by Ruan (1981) to be a junior synonym of Eocanites Librovich 1957. Cycloclymenia, Cryptoclymenia, Discoclymenia and Pseudoclymenia have long been recognised to be goniatites.

Horizon and distribution: Clymeniids are first known from the sandbergeri or delphinus Zones of the middle Famennian in western Europe, Urals and N. America, and they range up into the sphaeroides Subzone, near the Devonian-Carboniferous boundary. Examples are known from western and southern Europe, North Africa, Urals, Iran, Pakistan, Australia, south west China and western and eastern North America.

Suborder Gonioclymeniina Schindewolf 1923

Diagnosis: Clymeniida with a ventral lobe retained throughout ontogeny, although divided in some cases by a median saddle.

Description: Shell form is typically evolute with compressed quadrate whorl section, although some groups are globular or involute. Growth-lines are concavo-convex, or S-shaped, with a ventral sinus. Ribbing is common. Suture is variable with up to seven lobes (between venter and dorsum).

The Gonioclymeniina are divided into three superfamilies distinguished by their patterns of sutural elaboration: Sellaclymeniaceae, Parawocklumeriaceae and Gonioclymeniaceae. Sutures are generally more complicated in this suborder.

Superfamily Sellaclymeniaceae Schindewolf 1923

Diagnosis: Gonioclymeniina in which sutural elaboration takes place by addition of umbilical lobes, or subdivision of the ventral lobe.

Four families are recognised within the Sellaclymeniaceae: Glatziellidae, Sellaclymeniidae, Biloclymeniidae and Wocklumeriidae.

Family Glatziellidae Schindewolf 1928

Type genus: Glatziella Renz 1913b.
Diagnosis: Sellaclymeniaceae with simple suture consisting of ventral lobe, sometimes divided by a saddle, lateral lobe and sometimes umbilical and dorsal lobes. Coiling is evolute to involute and whorl section depressed to quadrate. Growth-lines consist of a lateral and ventral sinus. Strong concave ribs are common.

Two subfamilies are recognised: Hexaclymeniinae retaining a simple suture consisting of ventral, lateral and dorsal lobes, and Glatziellinae in which the suture is elaborated by subdivision of the ventral lobe, and addition of an umbilical lobe.

Horizon and distribution: The family ranges from the delphinus to paradoxa Zones. Some authors (Schindewolf 1949b, 1972; Bogoslovskiy 1976) consider Hexaclymenia, the oldest representative of the family, to be ancestral to all other clymeniids.

Subfamily Glatziellinae Schindewolf 1928

Diagnosis: Glatziellidae with subdivided ventral lobe.

Description: Suture consists of subdivided ventral lobe, lateral and internal lobes (Glatziella), and in Postglatziella there is an extra umbilical lobe (Textfig. 4.6). The shell form is varied, commonly strongly ribbed, and the venter has ventro-lateral grooves or depressions running around it.

Included genera:

Glatziella	Renz 1913b
Postglatziella	Schindewolf 1937a

Remarks: Sun and Shen (1965) introduced Sinoglatziella, which differs from Glatziella only by being smooth shelled and lacking ornament. No representatives of the Glatziellinae are described here.

Horizon: subarmata and paradoxa Zones.

Subfamily Hexaclymeniinae Lange 1929

Type genus: Hexaclymenia Schindewolf 1923a, p. 428.
Diagnosis: Member of the Hexaclymeniidae with simple suture consisting of a dorsal, a lateral and a ventral lobe (Textfig. 4.1C).

Included genera:

Hexaclymenia	Schindewolf 1923a
Progonioclymenia	Schindewolf 1937a
Soliclymenia	Schindewolf 1937a

Discussion: Stenoclymenia Lange 1929 has been placed in this family (Lange 1929). Its relationship to the genus Platyclymenia Hyatt is uncertain, but the latter is differentiated by the presence of a ventral saddle. This genus is discussed below. Weyer (1981) placed Soliclymenia in synonymy with Progonioclymenia and recognised only Hexaclymenia (Hexaclymenia) and Hexaclymenia (Progonioclymenia), but gave no reasons for his action. Presumably he united them because of their similar sutures.

Horizon and distribution: Representatives of the family are known from the middle Platyclymenia Stufe to the lower Wocklumeria Stufe of the Carnic Alps (Austria-Italy), Oberfranken, Rheinische Schiefergebirge (W. Germany), south western Poland, southern Urals

(USSR), and Kweichow,(south western China).

Genus Hexaclymenia Schindewolf 1923a

1981 Hexaclymenia Schindewolf - Bogoslovskiy, p. 38.

Type species: Genuclymenia hexagona Wedekind 1908, p. 619, pl. XLIII, figs. 7.7a, by original designation (monotypy) of Schindewolf (1923a, p. 428).
Diagnosis: Member of the Hexaclymeniinae with whorl section approaching hexagonal. Flanks and venter are flattened, between them runs a broad groove and there are distinct umbilical walls between the flanks and the seam. Growth-lines are concave over the umbilical walls and flanks, strongly prorsiradiate across the ventro-lateral groove, and form a sinus over the venter.

Remarks: Only the type species is known. House (1970, pl. 126) incorrectly designated the specimen figured by Wedekind (see above) as the holotype. The type series consisted of six specimens, so the specimen House figured must be termed the lectotype.
Two specimens of Hex. hexagona from the type locality of Enkeberg, Sauerland, are illustrated here (Pl. 5.1, Figs. 1-4).

Horizon and distribution: The genus is known from the middle Platyclymenia Stufe of the Rheinische Schiefergebirge (W. Germany), and from the southern Urals (USSR) (Perna 1914).

Genus Progonioclymenia Schindewolf 1937a

Type species: See the nominate subgenus.
Diagnosis: Hexaclymeniinae with strong concave or S-shaped ribs.

Included subgenera:

Progonioclymenia Schindewolf 1937a
Soliclymenia Schindewolf 1937a

Remarks: These two taxa, separated as genera by Schindewolf (1937a), are distinguished only by the presence or absence of a rim running around the ventro-lateral shoulder, and whorl form: *Progonioclymenia* compressed, *Soliclymenia* depressed, which are sufficient only for division of subgeneric, or even specific level.

Horizon and distribution: Schindewolf (1937a) believed that *Progonioclymenia* occurred in the *Clymenia* Stufe, and *Soliclymenia* in the *Wocklumeria* Stufe. Recently Bogoslovskiy (1981) has reported *Soliclymenia solarioides* from the *annulata* Zone.

Subgenus *Progonioclymenia* (*Progonioclymenia*) Schindewolf 1937a

* 1937a *Progonioclymenia* gen. nov. - Schindewolf, p. 55.
1981 *Progonioclymenia* Schindewolf - Bogoslovskiy, p. 40 (see here for full synonymy).
1981 *Progonioclymenia* Schindewolf - Ruan, p. 109.

Type species: *Clymenia acuticostata* Münster 1842, by original designation of Schindewolf (1937a, p. 55).
Diagnosis: *Progonioclymenia* with quadrate whorl section and flattened venter, bounded by a rim on the ventro-lateral shoulder. This definition is essentially unchanged from the review of Schindewolf (1937a, p. 55).

Description: Shell evolute and serpenticonic. Whorl section quadrate. The flattened, smooth venter may develop a broad, median groove in mature specimens. Ribbing is present on the flanks, which are bordered by a rim running around the ventro-lateral shoulder. The ribbing is strong, prorsiradiate or radial, sinuous, straight or concave and may modify in mature examples when ventro-lateral spines can develop. The suture (Textfigs. 5.1B,D) consists of dorsal, lateral and ventral lobes.

Available names include:

*acuticostata	Münster,	1842,	p. 126, pl. XII, figs. 6a-c, Schübelhammer, Oberfranken.
aegoceras	Frech,	1902,	p. 31, pl. II(I), figs. 5a-b, Grosser Pal, Carnic Alps.
ventroplana	Bogoslovskiy,	1981,	p. 41, pl. II, figs. 5-7, textfigs. 4c, 5a. R. Kiya, Aktubinskaya Oblast', USSR.

Horizon and distribution: This subgenus is known from the Clymenia Stufe of Oberfranken, Rheinische Schiefergebirge (W. Germany), south west Poland, Aktubinskaya Oblast', southern Urals (USSR) and Kweichow (south west China).

Progonioclymenia (Progonioclymenia) acuticostata (Münster 1842)

*	1842	Clymenia acuticostata sp. nov. - Münster, p. 126, pl. XII, figs. 6a-c.
p.(?)	1863	Clymenia speciosa Münster - Gümbel, p. 150.
non	1902	Clymenia aegoceras sp. n. - Frech, p. 31, pl. II(I), figs. 5a-b.
v non	1923a	Platyclymenia (?) acuticostata Braun - Schindewolf, p. 461, pl. XVII, fig. 12.
non	1937a	Progonioclymenia acuticostata (Braun) - Schindewolf, p. 56, pl. I, figs. 1-2.
non	1962	Progonioclymenia acuticostata (Braun) - Bogoslovskiy, pl. XXX, figs. 1a-b.
non	1981	Progonioclymenia acuticostata (Braun) - Bogoslovskiy, p. 40, pl. II, figs. 2-4, textfigs. 4d, 5b,c.

non 1981 Progonioclymenia acuticostata (Braun) - Ruan, p. 109, pl. 28, figs. 39-41.

Type material: The type species consisted of three specimens from Schübelhammer, Oberfranken (Münster 1842, p. 126) which are now missing from the Münster Collection in the BSP Munich. Therefore, any definition of this species must be based on Münster's figure of two specimens (1842, pl. XII, figs. 6a-c), or on similar specimens. The larger of the two specimens figured by Münster (figs. 6a,b) is designated as the lectotype.
Diagnosis: Progonioclymenia (Prog.) with S-shaped ribs.

Description: Münster shows two fragments which at a whorl height of 2-8mm have densely, sinuously ribbed, flattened flanks bounded by a rim running around the ventro-lateral shoulder, at the margin of a smooth flat venter.

Dimensions:

	WW	WH
Lectotype, Münster 1842, pl. XII, figs. 6a,b.	3.5	6

Remarks: Münster did not describe a suture for this species. Therefore it is assumed to have a suture similar to Prog. aegoceras, from the general morphological similarity of that species. Authorship of this species is generally attributed to Braun (see synonymy list), or even to Bronn (Ruan 1978). However, it must be given to Münster since there is no evidence that Braun wrote the original description, only that he found and gave the specimens to Münster, as he had also done for the species Cl. interrupta and Cl. dorsonodosa (Münster 1842, p. 126).

Frech established (1902, p. 31) a new species, Cl. aegoceras, which had concave ribs at a whorl height of 4mm but was otherwise similar to Münster's figure of Prog. acuticostata. In the explanation to his figures (1902, p. 41, pl. II(I), figs. 5a-b) Frech referred to the species as "Cl. acuticostata Münster = aegoceras". Frech's opinion is not accepted here since the rib courses are different in the two species. Schindewolf claimed (1923a, p. 460) to have compared the originals of Münster and Frech, and declared them to be conspecific. His opinion is not followed either, because of the differences in ornament. Unfortunately both of these specimens are missing, as is the specimen from Braunau, Wildungen upon which Schindewolf based his drawing of the suture (1937a, fig. 6). Two specimens of Progonioclymenia aegoceras are figured for comparison, One (Pl. 5.1, Figs.7,8, 14, 15, Textfig. 5.1A,B, Mbg. 3130) is from Braunau near Wildungen, and was figured by Schindewolf (1923a, pl. XVII, fig. 12). Bogoslovskiy's figures of a specimen from the Urals (1962, pl. XXX, figs. 1a-b; 1981, pl. II, figs. 2-4) have ribs which at a whorl height of between 3.5 and 6mm are straight, and one specimen (1962 supra cit., 1981, fig. 4) lacks a rim on the ventro-lateral shoulder. They are, therefore, not considered to be conspecific with Prog. acuticostata.

Horizon and distribution: This species is known from the Clymenia Stufe of Oberfranken. Korn (1981a) has used this species to name a zone in the Clymenia Stufe. Almost certainly he was referring to the species described here as Prog. (Prog.) aegoceras.

Progonioclymenia (Progonioclymenia) aegoceras (Frech 1902)

Pl. 5.1, Figs. 5-8,14,15; Textfigs. 5.1A,B,D.

* 1902 Clymenia aegoceras sp. nov. - Frech, p. 31, pl. II(I), figs. 5a-b.

v. 1923a Platyclymenia (?) acuticosta Braun - Schindewolf, p. 461, pl. XVII, fig. 12.

1937a Progonioclymenia acuticostata Braun - Schindewolf, p. 56, pl. 1, figs. 1-2.

1962 Progonioclymenia acuticostata (Braun) - Bogoslovskiy, pl. XXX, figs. 1a-b.

1981 Progonioclymenia acuticostata (Braun) - Bogoslovskiy, p. 40, pl. II, figs. 2-4; textfigs. 4d, 5b,c.

1981 Progonioclymenia acuticostata (Braun) - Ruan, p. 109, pl. 28, figs. 39-41.

Type material: The holotype, which was figured (see above) by Frech, came from Grosser Pal in the Carnic Alps and has not been traced.

Diagnosis: Progonioclymenia (Prog.) with concave or radial ribs and a grooved venter.

Description: Only one specimen, Mbg. 3130, is preserved well enough to be described. It is serpenticonic, with quadrate whorl section. The flattened venter has a shallow median depression at a diameter of 15mm. In early whorls, which appear to have a more rounded cross-sectional shape, raised concave lirae are visible up to a diameter of about 4mm (Pl. 5.1, Fig. 15). Thereafter broad, concave, slightly prorsiradiate ribs develop, which become radial on the last whorl seen, numbering 36 ribs. The weakly grooved venter is bounded by a rim. Growth-lines run parallel with the ribs over the flanks and form a deep sinus over the venter (Textfig. 5.1A, Pl. 5.1, Fig. 14).

Schindewolf figured a sagittal section (1937a, pl. 1, fig. 1) showing the septal necks. These were long, extending 60% of the distance between adjacent septa at an apertural height of 1.5mm, and becoming contiguous between the last two septae seen, at an apertural height of 3.7mm. The external suture, from Mbg. 3130, is shown in Textfig. 5.1B, and comprises a shallow lateral lobe and a ventral lobe. Schindewolf (1937a, textfig. 6) figured a suture from the same locality as Mbg 3130, and showed a V-shaped internal lobe (Textfig. 5.10).

Schindewolf included in this species a fragment from Hövel, Sauerland (1937a, pl. 1, fig. 2), no more than 6mm in length, showing only two ribs, which at a whorl height of 6mm were sinuous. It lacked a ventro-lateral rim, and the last rib seen was extended to form a spine protruding from the ventro-lateral shoulder. It is, of course, possible that sinuous ribs/loss of ventral rims, are mature characteristics, and therefore not specifically diagnostic.

Dimensions:

	D	U	WW	WH
Mbg 3130, Pl.5.1 Figs.7,8,14,15.	17.9	10.7	ca5	3.7
Mbg Pl.5.1, Figs. 5,6.	15.7	9.9	ca4	3.4

Remarks: The relationship of this species to *Prog. acuticostata* has been discussed under that species. To compare them material must become available from the Carnic Alps and Oberfranken. Most specimens, which previously have been assigned to these two species, have been collected in the Rheinische Schiefergebirge.

Horizon and distribution: Known from the *Clymenia* Stufe of the Carnic Alps, the Rheinische Schiefergebirge, Aktubinskaya Oblast', s. Urals and Kweichow. This species was used as an index for the lower *Clymenia* Stufe by Wedekind (1914).

Subgenus Progonioclymenia (Soliclymenia) Schindewolf 1937a

1957 Soliclymenia Schindewolf - Schindewolf, p. 140.
1962 Soliclymenia Schindewolf - Bogoslovskiy, p. 401.
1981 Soliclymenia Schindewolf - Bogoslovskiy, p. 42 (see here for full synonymy).

Type species: Goniatites solarioides von Buch (1838, p. 157, pl. 1, fig. 5) by original designation of Schindewolf (1937a, p.57).

The holotype of the species was figured by Schindewolf (1937a, pl. 1, fig. 3) but is now missing from the Museum für Naturkunde, Berlin.

Diagnosis: Progonioclymenia with rounded, depressed (? reniform) whorl section, lacking a rim running around the ventral margins.

Description: Evolute, serpenticonic, showing triangular to spiral coiling. Whorl section depressed and rounded. Ornament consists of strong concave prorsiradiate ribbing on the flanks, and growth-lines form a deep sinus over the smooth venter. Suture (Textfig. 5.1F) consists of a dorsal lobe, or broad lateral lobe and a ventral lobe.

Available species names include:

*solarioides	von Buch	1838, p. 157, pl. I, fig. 5, Dzikowiec, Poland.
paradoxa	Münster	1839, p. 14, pl. XVI, figs. 6a-d, Schübelhammer, Oberfranken.
recticosta	Ruan	1981, p. 108, pl. 27, figs. 4-7, textfig. 77, Kweichow.
semiparadoxa	Schindewolf	1937a, p. 60, pl. 1, fig. 5, Dzikowiec, Poland.

Remarks: The designation by Frech (1902, p. 43) of G. solarioides as the type of Cycloclymenia Hyatt, 1884, was invalid (Schindewolf, 1937a, p. 57). Authorship of Cycloclymenia was given to Hyatt by an ICZN ruling (Opinion 182) because Gümbel (1863, p. 100), in first publishing the name, had used the plural ending -eae for his "Untergattung" Cycloclymenieae. Although Hyatt (1884, p. 314) failed to nominate a type species for Cycloclymenia he had stated (1884, p. 313) that he used Gümbel's name in the sense of the original author. Since Gümbel's Untergattung Cycloclymenieae contained only the species Planulites planorbiformis Münster, 1832 this automatically became the type species, by monotypy, of Hyatt's genus Cycloclymenia.

Horizon and distribution: This subgenus is known from Oberfranken, Dzikowiec, Bashkirskaya ASSR, and Kweichow, from levels presumed to lie in the lower Wocklumeria Stufe, but Bogoslovskiy (1981) reported a specimen from the Platyclymenia Stufe.

Progonioclymenia (Soliclymenia) paradoxa (Münster 1839)
Textfig. 5.1E

* 1839 Clymenia paradoxa sp. nov. - Münster, p. 14, pl. XVI, figs. 6a-d.

1843 Clymenia paradoxa Münster - Münster, p. 41, pl. XVI, figs. 6a-d, (copy of Münster 1839).

vp 1937a Soliclymenia paradoxa Münster - Schindewolf, p. 60, pl. 1, figs. 4b,6-8.

1981 Soliclymenia paradoxa (Münster) - Ruan, p. 108, pl. 27, figs. 1-3, textfig. 76.

Type material: The holotype has been missing from Munich at least since the time that Frech wrote (1902, p. 63).
Diagnosis: Soliclymenia with triangular coiling, and whorl section which is depressed and has a venter with two shallow grooves running around it.

Remarks: Schindewolf described the species using five museum specimens, which all came from Dzikowiec (formerly Ebersdorf), in Poland. The one figured by Tietze (1871, pl. XVI, fig. 4) is believed to have been destroyed with the collections at Wrocław during the last war, so that the only remaining specimens are in the GPI, Göttingen, and the British Museum (NH), (BM 66384).

Horizon and distribution: Besides the type locality of Schübelhammer, Oberfranken, the species is also known from Dzikowiec, and Kweichow. Since no examples of <u>Parawocklumeria</u> have been reported from Schübelhammer, the species is presumed to come from the lower <u>Wocklumeria</u> Stufe.

Family Sellaclymeniidae Schindewolf 1923b

Type genus: *Sellaclymenia* Hyatt 1884.
Diagnosis: Sellaclymeniaceae with suture consisting of ventral lobe, which may be subdivided by a saddle, lateral, umbilical and dorsal lobes, of which the lateral lobe is the largest. Growth-lines are S-shaped.

Two subfamilies are recognised:

Sellaclymeniinae Schindewolf 1923b
Costaclymeniinae Ruzhencev 1957

Remarks: These two subfamilies, previously given family rank (Bogoslovskiy 1981), are grouped together here, recognising that the only difference between them is the divided nature of the ventral lobe in the Sellaclymeniinae. Although the ontogeny of the suture in *Sellaclymenia* is unknown, the ventral saddle is presumed to have arisen secondarily, on the ventral lobe.

Horizon and distribution: see the included subfamilies.

Subfamily Sellaclymeniinae Schindewolf 1923b

Type genus: *Sellaclymenia* Hyatt 1884.
Diagnosis: Member of the Sellaclymeniaceae with a suture consisting of a broad ventral lobe divided by a median saddle, a large lateral lobe, an umbilical lobe, and a dorsal lobe (Textfig. 4.7A).

Included genus:

Sellaclymenia Hyatt 1884

Horizon and distribution: Species occur in the *Clymenia* and *Wocklumeria* Stufen of Oberfranken and the Rheinische Schiefergebirge (W. Germany).

Genus Sellaclymenia Hyatt 1884

* 1884 Sellaclymenia gen. nov. - Hyatt, p. 314
1981 Sellaclymenia Hyatt - Bogoslovskiy, p. 50 (see here for synonymy.

Type species: Clymenia angulosa Münster 1839 (= Planulites planus Münster 1832), by original designation of Hyatt, 1884.
Diagnosis: As for the Sellaclymeniinae.

Description: Evolute with compressed whorl section, parallel flanks and flattened venter. Shell smooth, or with pronounced ribs terminated by strong ventro-lateral tubercles, present on the phragmocone only. Growth-lines S-shaped with a sinus over the venter. The suture has a broad ventral saddle, bounded by shallow ventro-lateral lobes, broad V-shaped lateral lobe, an umbilical lobe and a dorsal lobe.

Available specific names include:

*angulosa	Münster	1839, p. 12, pl. XVI, figs. 2a-c, Schübelhammer, Oberfranken.
planidorsata	Münster	1839, p. 36, Gattendorf, Oberfranken.
planus	Münster	1832, p. 32, pl. VI, figs. 4a-c, Schübelhammer, Oberfranken.
?semicostata	Münster	1839, p. 13, pl. XVI, figs. 2a-d, Schübelhammer, Oberfranken.
spinosa	Schmidt	1924, p. 136, pl. 7, fig. 8,a, Dasberg, Sauerland.
torleyi	Wedekind	1914, p. 58, pl. 6, fig. 1, Hövel, Sauerland.

Remarks: The type species, Sell. angulosa, may be a junior subjective synonym of Sell. plana. This is discussed below.

Sellaclymenia planidorsata and semicostata are two poorly known species which are regarded as nomina dubia. There are two unnumbered specimens in the BSP Munich, which are associated with a "Cl. planidorsata Gattendorf" label, one of which is a Kosmoclymenia, and the other is too poorly preserved to identify.

Sellaclymenia semicostata is a species which is difficult to interpret. Münster's figure (1839, pl. XVI, fig. 2) shows a lateral view (fig. 2a) and a ventral view (fig. 2b) of a fragment of a whorl still attached to a piece of limestone, a fragment of a larger specimen (fig. 2c) and a Sellaclymenia-type suture (fig. 2d). The accompanying description (1839, p. 13) stated that the figured specimen (sic, i.e. singular) was to be found in de Verneuil's collection, but showed no sutures. This specimen is presumably the one in figs. 2a,b. Münster then stated that he possessed another fragmentary specimen (presumably that in figs. 2c,d) which showed the suture.

Neither of these two specimens has been located (but see below), nor any resembling Münster's description. Therefore no types are recognised. If Münster's observations were correct the species would seem to be diagnosed as a Sellaclymenia with a quadrate whorl section and strongribbing which runs either prorsiradiately or rursiradiately. The ribbing orientation is uncertain because there is no indication of the direction of the aperture in Münster's figures.

Gümbel (1863, p. 150, pl. XIX, figs. 3a-b) figured and described a specimen which he considered to be Münster's original of Cl. semicostata. This specimen (BSP AS VII 592) has a broad ventral lobe not divided by a saddle and this, with its small size and ornament precludes it from being either of the specimens Münster figured. The sutural ontogeny of Sellaclymenia is unknown, so this specimen can only questionably be assigned to Sellaclymenia. The specimen (Pl. 5.10, Figs. 3,4) has inner whorls which are smooth, and at a diameter of ca18mm tubercles are developed on the ventro-lateral shoulder. The maximum diameter is ca 24mm, therefore this specimen cannot be compared with either of Münster's figures of the species, which seem (if the illustration is at natural size) to have a diameter of at least 35mm. The ornament on this particular specimen develops too late for it to be considered as Sell. torleyi (see below), and so it is identified as Sellaclymenia sp.

There is in the BSP Munich a specimen (AS VII 591, Pl. 5.10, Figs. 1,2) associated with a Cl. semicostata label which has closely spaced straight prorsiradiate ribs, as in Münster's figure of semicostata. The ribs continue over the venter, and form a shallow sinus, centred on a shallow mid ventral depression. Münster made no comments about the nature of the venter in his description. The suture is only poorly visible, yet clearly shows a deep ventral lobe, and is of Gonioclymenia-type over the flanks. This then is a specimen, the ornament of which has affinities with Münster's figure of semicostata, but also has a Gonioclymenia-type suture, but only a shallow ventral groove. It is thus transitional between Gonioclymenia and Kalloclymenia. It is mentioned here in an attempt to identify Cl. semicostata, but the evidence is too inconclusive to state that it is not a Sellaclymenia.

Wedekind described Sell. torleyi as a Gonioclymenia (1914, p. 58), although he recognised that the ventral lobe was possibly divided by a median saddle. This latter point has been confirmed by an examination of the lectotype (RE 551.734.5 A254, Pl. 5.33, Figs. 2,3, Textfig. 5.2E). Lange (1929, p. 74) recognised that the species was a Sellaclymenia and that Sell. spinosa Schmidt (Pl. 5.33, Figs. 15,16, Textfig. 5.2O) was synonymous with it.

This species is described below.

Wedekind (1914) referred the Münster species angusta to Sellaclymenia, apparently by reference to a specimen in Berlin. No such specimen can be found today, and the species Gon. angustus will be discussed (see below under Gonioclymeniidae, Remarks).

Horizon and distribution: The genus is known from Oberfranken, Rheinische Schiefergebirge (W. Germany), ranging from the Clymenia Stufe, to the Wocklumeria Stufe (contra Textfig. 4.5).

Sellaclymenia plana (Münster 1832)

Pl. 5.10, Figs. 5-12, Textfigs. 2,3.

v*	1832	Goniatites planus sp. nov. - Münster, p. 30, pl. VI, figs. 4a-c.
	1834b	Goniatites planus Münster - Münster, p. 92, pl. VI, figs. 3a-c, (French translation of Münster 1832).
v	1839	Clymenia angulosa sp. nov. - Münster, p. 12, pl. XVI, figs. 2a-c.
(?)	1839	Clymenia planidorsata sp. nov. - Münster, p. 36.
	1843	Goniatites planus Münster - Münster, p. 23, pl. VIa figs. 4a-c, (copy of Münster 1832).
		Clymenia angulosa Münster - Münster, p. 40, pl. XVI, figs. 2a-c, (Copy of Münster 1839).
		Clymenia planidorsata Münster - Münster, p. 36,
vp	1863	Clymenia angulosa Münster - Gümbel, p. 149, pl. XIX, figs. 2a-c.
vp	1902	Gonioclymenia plana Münster - Frech, non pl. II(I), fig. 4, textfig. $6b_{1-5}$ (p. 38).
pv	1923a	Sellaclymenia angulosa Münster - Schindewolf, p. 485.
non	1924	Gonioclymenia plana Münster - Schmidt, p. 140.

Type material: BSP AS VII 594, from Schübelhammer, Oberfranken, is designated here as the lectotype. The counter-part of this specimen, MfN c601 (Pl. 5.10, Fig. 10) is in the Museum für

Naturkunde, Berlin.

Münster's (1833) catalogue of his collection lists only one specimen, but the original description (Münster 1832) seems to use more than one. No paralectotypes have been identified.

Diagnosis: Sellaclymenia with a smooth shell at all stages and very compressed whorl section.

Description: Two specimens have been examined, the proposed lectotype, BSP AS VII 594, and the lectotype of Cl. angulosa, proposed here as BSP AS VII 589.

The first part of the description applies equally to both specimens. Evolute shell, with compressed whorl section and flat umbilical area. Whorl section is compressed with umbilical wall, flat converging flanks and flattly rounded venter (Pl. 5.10, Figs. 8,11). Growth-lines are S-shaped with a sinus over the venter (Textfig. 5.2B) strong secondary ornament is absent but BSP AS VII 594 has very faint ribs on the internal mould, at a diameter of ca 40mm.

Similar suture lines are visible on both specimens (Textfigs. 5.2B,C). Over the flanks the suture greatly resembles Gonioclymenia, but the ventral lobe is divided by a saddle. In sagittal-section (visible on BSP AS VII 594) one septum shows two saddles (Pl. 5.10, Fig. 6). The early suture can be seen on the same specimen at a diameter of ca 10mm and here the elements are rounded (Pl. 5.10, Fig. 7). (The rounded elements of the suture at this stage may suggest that Sellaclymenia has a closer affinity to Biloclymenia than Costaclymenia.) The siphuncle is visible on BSP AS VII 594 at a diameter of ca 50mm, where it is reniform, the base being raised, apparently to accommodate the keel of the wrinkle layer (Textfig. 5.24). It is approximately 2mm in height and the septal necks run together to form a continuous tube.

Dimensions:

	D	U	WW	WH
Lectotype; BSP AS VII 594	80.5	28	ca17	32.2
	75.7	27	vca15	30
			9.2	17.3
			12.8	20.5
			3.8	5.4
			5.1	7.6
Lectotype of Cl. angulosa Münster BSP AS VII 589	43.3	17.8	ca12.5	17.8
	34.5	13.1	ca 8.4	12

Remarks: Münster's original figure of this species shows (1832, pl. VI, fig. 9c) a ventral lobe. However, the lectotype so greatly resembles the figure in other respects, such as size, ornament, that it is considered that Münster either figured the suture incorrectly, or based it on another specimen. Münster's description appears to be based on more than one specimen yet the catalogue of his collection (Münster 1833) refers to one only. In view of this contradiction the type specimen is referred to as the lectotype. Similar contradictions can be found in the references to other species, e.g. Gon. speciosa and Gon. spuria. (Even more strange is the reference (Münster 1832, p. 21) to only one specimen of Paratorleyoceras globosum, since two are shown in the original figure (Münster 1832, pl. IV, figs. 4a-c)).

The counterpart (MfN c601) of the lectotype has been recognised in Berlin, and it is probably this specimen that was referred to by Frech (1902, p. 39) and Wedekind (1914, p. 57), only the latter of whom correctly recognised its genus. Schmidt's (1921, p, 333, 1924, p. 140) use of this specific name as a Gonioclymenia was justified by saying that the specimens he had collected (probably various specimens of Gen. Nov. A) resembled Münster's (1832) figure. Frech (1902, textfig. 5_3) also figured a suture of a Sellaclymenia, which he referred to as "Sell. angulata Mstr". This misnaming may be based on a mistakenly written museum label, cf. SM H10402.

Schindewolf (1923a) recognised that the Münster species plana and angulosa were synonymous, based on an examination of the two specimens described here but, inexplicably, gave priority to angulosa.

An undescribed species of Gen. Nov. A, similar to frechi, but lacking any ribbing or tuberculation, greatly resembles Sell. plana, and is differentiated only by the presence of a ventral lobe.

Horizon and distribution: This species was reported from the *Wocklumeria* Stufe by Schindewolf (1923a).

Sellaclymenia torleyi (Wedekind 1914)

Pl. 5.33, Figs. 2,3, Textfigs. 5.2D,E

v* 1914 *Gonioclymenia torleyi* sp. nov. - Wedekind, p. 58, pl. VI, fig. 1.
v 1924 *Sellaclymenia spinosa* sp. nov. - Schmidt, p. 136, pl. 7, fig. 8.
1929 *Sellaclymenia torleyi* Wedekind - Lange, p. 74.

Type material: RE 551.734.5 A254, Torley Collection, from Hövel, illustrated in Pl. 5.33, Figs. 2,3, is proposed as the lectotype.
Diagnosis: *Sellaclymenia* with compressed quadrate whorl section, which develops strong ventro-lateral tubercles after a diameter of ca 10mm.

Description: Three specimens have been examined: the lectotype, RE 551.734.5 A124, a second specimen in the Torley Collection, and MfN c596, Haarman Collection, Dasberg, which is proposed as the lectotype of *Sellaclymenia spinosa* Schmidt 1924, and is regarded as conspecific with *Sell. torleyi*.

The lectotype is a reasonably well preserved specimen, fractured, but retaining shell material and showing the suture. Coiling is evolute, and the whorl section compressed (WW/WH = 0.56). Early whorls are smooth, and although not sectioned, appear quadrate. Weak indications of tubercles near the ventro-lateral shoulder appear at a diameter of ca 7mm. These rapidly increase in size and spread across the flank to form weak ribs. By a diameter of 38mm the tubercles protrude at the ventral shoulder, such that they double the whorl width; their frequency is approximately 18 per whorl. Growth-lines more widely spaced over the tubercles, are first visible at a diameter of 22mm, where they are prorsiradiate, weakly S-shaped and form a deep sinus, U-shaped, over the venter. Over the fraction of the body chamber which is missing from the lectotype the tubercles and the ribs must diminish in strength, because at a diameter of 50mm only the lirate growth-lines remain of the ornament. The venter has a shallow depression running along it, and the whorl section is compressed, quadrate, with the flattened flanks converging slightly onto the venter. A small area of wrinkle-layer is preserved at a diameter of 28mm, where, on the venter, there is a series of subparallel anastomosing striae running from side to side, A fine string-like keel runs along the middle of the venter, suggesting that the body chamber of this individual extended for a further quarter whorl, making it just over a whorl in length.

The suture (Textfig. 5.2E) is visible at a diameter of 27mm and shows the characteristic tongue-shaped lateral lobe, and ventral saddle.

A second, weathered, specimen (RE 551.734.5 A124) from the type locality, adds little to our knowledge of the species. Tubercles appear at a diameter of approximately 14mm and the last septum was formed at a diameter of ca 60mm.

The lectotype (MfN c596) of Sell. spinosa Schmidt, the precise collecting horizon of which is unknown, resembles Sell. torleyi in gross morphology, but there are several minor differences, particularly in the tubercular ornament. Tubercles are developed later, (D = 11), increase in size more slowly, have a lower frequency (ca 12 per whorl), are associated with feeble low ribs at the umbilical shoulder, and have disappeared by a diameter of ca 30mm. The body chamber is preserved through 180^{o}, and there are very weak S-shaped plications on the internal mould. Suture and growth-lines are illustrated in Textfig. 5.2D; elements of the suture are somewhat subdued through polishing. The growth-lines have a much shallower ventral sinus where there are no ventro-lateral tubercles.

Dimensions:

	D	U	WW	WH
Lectotype,	55.9	25.3	10.4	18.7
RE 551.734.5 A254	37.9	18	10	-
RE 551.734.5 A124	36.5	16.6	8	12.4
MfN c596	56.1	22.7	12.3	20
(lectotype of Sell. spinosa)	51	21.3	11	18.9

Comparisons: Sellaclymenia plana is easily distinguished by its lack of strong sculpture. Species of Gonioclymenia and Kallo-clymenia are difficult to distinguish without knowledge of the suture over the venter. However they do possess very pronounced ventro-lateral tubercles early in ontogeny, which extend ventrally rather than laterally, and generally these develop into ribs extending across the middle of the flank (e.g. Pl. 5.4, Figs. 2,3,5).

Remarks: Wedekind included this species within Gonioclymenia, even though he stated (1914) that there may have been a ventral saddle, rather than a ventral lobe. Lange (1929) found a single specimen at the type locality, and recognised the species to belong to Sellaclymenia.

Horizon and distribution: This species is known only from the Clymenia Stufe of the Sauerland where Wedekind reported it from $V\alpha$ (although there is some ambiguity in his wording, viz. "unter Laevigata-Kalken-$V\beta$-"). Lange reported his specimen from $V\alpha$.

Subfamily Costaclymeniinae Ruzhencev 1957

Type genus: Costaclymenia Schindewolf 1920.
Diagnosis: Member of the Costaclymeniidae with a suture (Textfigs. 4.7C,D) consisting of a broad ventral lobe, a broad asymmetric trough-shaped lateral lobe, a very shallow umbilical lobe, centred outside the umbilical seam, and a dorsal lobe.

Included genera:

Endosiphonites (Costaclymenia)	Schindewolf 1920
Endosiphonites (Endosiphonites)	Ansted 1838
Mesoclymenia	Bogoslovskiy 1981

Remarks: Trochoclymenia Schindewolf 1923 may belong in this subfamily. One of its species, Troch. wysogorskii (Frech) has a suture with a ventral saddle, a broad lateral lobe, a shallow umbilical lobe, and a dorsal lobe (Textfig. 4.12C). The other species (Troch. ornata Petter) has a suture which is homeomorphic with Costaclymenia, save that it has a ventral saddle (Textfig. 4.12D). An alternative, and more likely interpretation, is that Trochoclymenia is derived from Platyclymenia by the addition of an umbilical lobe.

Comparisons: End. (Costaclymenia) has ribbed or tubercular ornament, whereas End. (Endosiphonites) is smooth, or nearly so. Mesoclymenia has a pointed symmetric lateral lobe.

Horizon and distribution: The family seems to be largely confined to the Clymenia Stufe of England, Germany, Poland, USSR, and probably the USA. The earliest species, End. (Cost.) multicostata, has been reported from the annulata Zone of Kazakhstan (Bogoslovskiy 1981). Thus it can be argued that Endosiphonites, and hence the Gonioclymeniina can be derived from the morphologically similar Stenoclymenia (see Chapter 4).

Subgenus Endosiphonites (Endosiphonites) Ansted 1838

* 1838 Endosiphonites gen. nov. - Ansted, p. 416.

Type species: Endosiphonites muensteri Ansted 1838 proposed herein.
Diagnosis: Endosiphonites with shallow ventral lobe, and ornament which is subdued or absent. Prominent ribs are not developed.

Description: This subgenus has weak ornament consisting of small ventro-lateral tubercles and faint plicate ribs, in contrast to the blunt strong ribs and tubercles of End. (Costaclymenia).

Remarks: This generic name was proposed by Ansted (1838) as a replacement for Clymenia Münster 1834, on the grounds that the name better described the distinctive character of the genus, namely the ventrally positioned siphuncle. Ansted described three species as Endosiphonites: End. carinatus (SM H4011) which is a Kosmoclymenia sp., End. minutus (SM H4012), which is a ?Clymenia sp., and End. muensteri (SM H4010). The last named was the largest and best preserved of the three specimens, and the one on which Ansted observed the position of the siphuncle. Therefore, it is most appropriate that this species should be formerly designated as the type species and thus legitimize this long ignored genus. End. (End.) enodis lacks all ornament; the holotype (MfN) is illustrated in Pl. 5.2, Figs. 10,11.

Available species names include:

*	muensteri	Ansted 1838, p. 419, pl. VIII, fig. 1, South Petherwin.
?	bowsheri	Miller and Collinson 1951, p. 601, fig. 1, Hillsboro, New Mexico.
	enodis	Schindewolf 1926, p. 108, Braunau, Kellerwald.

Horizon and distribution: This subgenus is known from the Clymenia Stufe of south west England, Rheinische Schiefergebirge, Algeria, and possibly from the USA (New Mexico).

Endosiphonites (Endosiphonites) muensteri Ansted 1838

Pl. 5.2, Figs. 12,13, Textfig. 5.4A

v*	1838	Endosiphonites Münsteri sp. nov. - Ansted, p. 419, pl. VIII, figs. 1, 4?
v	1852	Clymenia Muensteri Ansted - M'Coy, p. 402, pl. 2A, fig. 12, (refiguring of the holotype).
?	1950	Costaclymenia binodosa Münster - Termier and Termier, p. 77, pl. CLX, figs. 28-10.
v	1960	Costaclymenia muensteri Ansted - Selwood, p. 157, pl. 26, fig. 1, (refiguring of the holotype).
?	1960	Costaclymenia cf. enodis Schindewolf - Petter, p. 12, pl. III, figs. 10,a-c, textfig. 2B, (refiguring of the Termiers' specimen).

Type material: The holotype, SM H4010, from the Petherwin Beds, Launceston, Cornwall, is refigured here (Pl. 5.2, Figs. 12,13, Textfig. 5.4A).

Diagnosis: Endosiphonites with faint ribbing.

Description: Only the holotype has been seen. The whorl section is compressed with flattened, converging flanks, and a flatly rounded smooth venter. The early whorls are smooth. Traces of ribs appear by a diameter of ca 20mm and there are approximately 30 weak, concave, prorsiradiate ribs in the whorl prior to a diameter of 45mm. Thereafter the ribs diminish in strength, becoming more closely spaced, radial and S-shaped on the body chamber.

Dimensions:

	D	U	WW	WH
Holotype, SM H4010	97.8	40.4	15.9	36
Pl.5.2,Figs.12,13	73	32.8	11.8	25.7

Remarks: In his text Ansted (1838, p. 419) states, "... as will be clearly seen from the figure, shows the siphuncle very clearly". It is equally clear that Ansted's pl. VIII, fig. 1 does not show the siphuncle. Selwood (1960, p. 158) drew attention to the fact that in M'Coy's figure the holotype was missing several chambers and had been subsequently restored, and was now lacking only one. It is suggested that this chamber, marked by an "a" in Ansted's fig. 1, was removed and figured by Ansted separately (pl. VIII, fig. 4), also marked with an "a", to show the nature and position of the siphuncle.

A specimen from Braunau near Wildungen (MfN, Pl. 5.2, Figs. 1,11), figured by Schmidt (1924, pl. 6, figs. 31a) as Costaclymenia wysogorskii (Frech) was subsequently designated the holotype of Costaclymenia enodis (Schindewolf 1937a, p. 25). As the name suggests this species lacks ornament, although Schmidt (1924, p. 130) stated that there were traces of umbilical ribs on middle-sized specimens. In either case the ornament is subdued, therefore this species is assigned to the subgenus End. (Endosiphonites). Apart from the ribbing the only apparent difference between this species and End. (End.) muensteri is the whorl cross-sectional shape, although this is difficult to compare since the holotypes are of different sizes. End. (Endosiphonites) enodis has almost parallel whorl flanks and End. (End.) muensteri has converging whorl flanks.

A series of weak ribs and a whorl section with converging flanks are visible on the specimen figured by Termier and Termier (1950, pl. CLX, figs. 28-30) and Petter (1960, pl. III, figs. 10a-c), and thus it seems closer to End. (End.) muensteri than to End. (Cost.) binodosa (as Termier and Termier suggested) or End. (End.) enodis (as Petter suggested).

Attention must also be drawn to the resemblance between End. (End.) muensteri and Falciclymenia bowsheri Miller and Collinson (1951, p. 600), I have examined a plaster cast of the holotype of Falc. bowsheri (SM H7366, Pl. 5.33, Figs. 8,9) in the Sedgwick Museum, Cambridge, and I believe that the whorl section as figured by Miller and Collinson (1951, fig. 1) has too acute a venter and that the impressed area is too deep. Also the ventral area is very worn and it is impossible to say whether there was a simple ventral saddle or if it was divided by a median lobe. Consequently this species, which lacks ornament, cannot with certainty be excluded from either Trochoclymenia or End. (Endosiphonites). Further discussion of this species is presented under Gen. Nov. F, below.

Horizon and distribution: End. (End.) muensteri is known from the <u>Clymenia</u> Stufe of Cornwall and Algeria, and possibly from New Mexico, USA.

Subgenus <u>Endosiphonites</u> (<u>Costaclymenia</u>) Schindewolf 1920

*	1920	<u>Costaclymenia</u> gen. nov. - Schindewolf, p. 127.
	1981	<u>Costaclymenia</u> Schindewolf - Bogoslovskiy, p. 44 (see here for full synonymy).

Type species: <u>Goniatites</u> <u>binodosus</u> Münster 1832, by original designation of Schindewolf (1920, p. 127).
Diagnosis: <u>Endosiphonites</u> with flanks possessing a ribbed or strongly tubercular ornament.

Description: Evolute, widely umbilicate, with rectangular compressed whorl section. Strong ribs, following the same course as the slightly prorsiradiate concave growth-lines across the flanks, are sometimes terminated by ventro-lateral and umbilico-lateral tubercles. Early whorls are smooth. Suture (Textfig. 4.7) with shallow rounded ventral lobe, broadly rounded lateral lobe, shallow rounded umbilical lobe outside the umbilical seam, and deep pointed dorsal lobe.

Available species names include:

*	<u>binodosa</u>	Münster 1832, p. 31, pl. IV, figs. 5a-b, Schübelhammer, Oberfranken.
	<u>crassa</u>	Schindewolf 1921, p. 122, <u>nom</u>. <u>nud</u>.
	<u>kiliani</u>	Wedekind 1914, p. 61, pl. VI, fig. 4, Dasberg, Sauerland.
	<u>multicostata</u>	Bogoslovskiy 1981, p. 47, pl. IV, figs. 3,4, textfigs. 6b, 8, R. Kairakty, Karagandinskaya Oblast'.

Remarks: Endosiphonites has priority over Costaclymenia and thus becomes the nominate genus. Costaclymenia binodosa has been interpreted by authors (e.g. Schindewolf 1920, 1923a, Lange 1929, Petter 1960) on the basis of Münster's second (1839) and more detailed figure (see End. (Cost.) binodosa, below, for a discussion of Münster's usage of the specific name). This apparent example of deliberate misquotation of the type species of Costaclymenia binodosa could be considered as sufficiently explicit to warrant invoking the relevant part of the Code (1964), Article 70(b) on "Deliberate use of misindentification" which states:

> If the type designated for a new nominal genus is a previously established species, but the designator states that he employs its specific name in accordance with the wrong usage of a previous author, the type species is to be interpreted as the one actually before the designator, not the one that correctly bears the name.

The actual statement of Schindewolf (1920, p. 127) was "... dem Genotyp; Costaclymenia binodosa Mstr sp. (Clymenia binodosa Muenster, a. a. O." (Münster 1843) "S.24 u. 37, Taf. VIa, Fig. 5a,b, Taf. II, Fig. 3a-c."

The only figure Schindewolf gave of the suture (1920, fig. 2a) conforms to Münster's later figure (1839, pl. II, figs. 3a-c) and the intention of the Code would seem to be to legitimize Costaclymenia binodosa Schindewolf 1920, with Clymenia binodosa Münster 1839, pl. II, figs. 5a-c, as its holotype. The precise wording of Art. 70(b), however, defeats this aim because Schindewolf not only used binodosa in the "wrong usage of a previous author" (Münster 1839, pl. II, figs. 5a-c) but also in the correct usage of a previous author (Münster 1832, pl. II, figs. 5a-c). Therefore it is the correct oldest usage of binodosa which is valid and relevant.

Horizon and distribution: This subgenus is known from the *Platyclymenia* Stufe of Kazakhstan, and the *Clymenia* Stufe of the Rheinische Schiefergebirge, Oberfranken (W. Germany), the Holy Cross Mountains (Poland), Urals and Kazakhstan (USSR).

Endosiphonites (*Costaclymenia*) *binodosa* (Münster 1832)

Pl. 5.2, Fig. 1

*	1832	*Goniatites binodosus* sp. nov. - Münster, p. 31, pl. VI, figs. 5a-b.
	1834b	*Goniatites binodosus* Münster - Münster, p. 94, pl. V, figs. 6a-b (French translation of Münster 1832)
non.	1839	*Clymenia binodosa* Münster - Münster, p. 9, pl. XII, figs. 3a-c.
	1843	*Clymenia binodosa* Münster - Münster, p. 21, pl. VIa, figs. 5a-c (copy of Münster 1832).
non.	1843	*Clymenia binodosa* Münster - Münster, p. 37, pl. XII, figs. 3a-c (copy of Münster 1839).
non.		all subsequent references to *binodosa*, which are listed under *Costaclymenia kiliani* (Wedekind).
non.	1871	*Clymenia binodosa* Münster - Tietze, p. 134, pl. XVI, figs. 10, (non 11), (see Schindewolf 1937a, p. 26).
non.	1902	*Clymenia binodosa* Münster - Frech, p. 33, pl. V(IV), fig. 3.
non.	1962	*Costaclymenia binodosa* Münster - Ruzhencev, pl. XXX, figs. 2a-b.
p.	1981	*Costaclymenia binodosa* (Münster) - Bogoslovskiy, p. 45, pl. III, fig. 1, pl. IV, figs. 1,2, textfigs. 6a,7.

Type material: A neotype, MfN, from Elbersreuth, Oberfranken, is proposed here.

The holotype, from Schübelhammer, figured by Münster (1832), as a fragment of body chamber, cannot be traced in the BSP. Münster (1839, pl. XII, figs. 3a-c) subsequently figured another specimen which he considered to be conspecific with it, and there are a number of specimens from his collection resembling this later figure in various museums. None of these is regarded to be conspecific with the specimen originally figured, and so a neotype, MfN, labelled as from Elbersreuth (a few kilometres from Schübelhammer, and quite possibly from the same locality), Oberfranken, is proposed.

Diagnosis: Costaclymenia with spinose ventro-lateral and umbilico-lateral tubercles, and lacking strong ribs joining them.

Description: Münster's figure of the holotype (1832, pl. VI, figs. 5a-b) shows a fragment of body chamber 35mm in length with a whorl height of 13mm and a whorl width of 12.5mm, increasing to 15.5mm over the tubercles which develop on the ventro-lateral shoulder. These are joined by a rib to less pronounced tubercles on the umbilico-lateral shoulder. On the original figure the ribs are shown ambiguously as prorsiradiate and rursiradiate, and with the umbilico-lateral tubercles joined by them to either one or two ventro-lateral tubercles.

A description of the species, conforming with Münster's first figure, is based solely on the neotype, MfN, (Pl. 5.2, Fig. 1). This has ventro-lateral tubercles which are pronounced, being almost spinose, low rectiradiate ribs, numbering 15 in the half whorl prior to a diameter of 60mm, and a Costaclymenia-type suture visible on the flank. Most of the phragmocone of the neotype is missing, so the nature of the inner whorls is unknown.

Dimensions:

	D	U	WH
Neotype, MfN Pl.5.2,Fig.1.	60	31.5	16.2

Remarks: A neotype must be designated for this widely used species name because it has been subject to various interpretations, none of which have as their basis Münster's original figure, and no specimen from the type series has been traced. Münster (1839, pl. XII, figs. 3a-c) figured another specimen without ventro-lateral tubercles on the body chamber, which he believed was conspecific with his earlier figure. This is considered to be incorrect, and specimens resembling this figure are placed in the species _End_. (_Cost_.) _kiliani_ (Wedekind).

Endosiphonites (_Costaclymenia_) _binodosa_ is the type species of the subgenus _Costaclymenia_ Schindewolf. However, Schindewolf and later authors have interpreted this species, and thus the genus, on the basis of Münster's 1839 figure (see above).

The course of the suture over the venter cannot be seen on the neotype, therefore Schindewolf's definition of the suture of _Costaclymenia_ is questionable. _Trochoclymenia_ Schindewolf 1926, has a similar suture over the flank, but is distinguished by the presence of a ventral saddle. If _End_. (_Cost_.) _binodosa_ is found to have a ventral saddle then _Trochoclymenia_ would become a subjective synonym of _Costaclymenia_.

Bogoslovskiy has recently (1981) described _Cost_. _binodosa_ using 20 examples from the southern Urals. In the synonymy he interprets the specific name broadly to include _Cost_. (_Cost_.) _kiliani_. Three of the examples he illustrated show ornament like the neotype, with tubercles on the flank margins, lacking strong ribs running between them, but the other large specimen (D=190), apart from having no ornament on the last whorl, has strong ribs at smaller diameters, more like _End_. (_Cost_,) _kiliani_.

The highly ribbed specimen which Bogoslovskiy (1962) assigned to _Cost_. _binodosa_, has recently (Bogoslovskiy 1981), been referred to a different species, _Cost_. _multicostata_.

Horizon and distribution: This species is known from the lower _Clymenia_ Stufe of Oberfranken, the southern Urals and Iran (_fide_ Bogoslovskiy 1981).

Endosiphonites (Costaclymenia) kiliani (Wedekind 1914)

Pl. 5.1, Fig. 11, Pl. 5.2, Figs. 2-9, Textfigs. 5.4B-F

v. 1839 Clymenia binodosa Münster - Münster, p. 9, pl. XII, figs. 3a-c.

v. 1843 Clymenia binodosa Münster - Münster, p. 37, pl. XII, figs. 3a-c (copy of Münster 1839).

v. 1863 Clymenia binodosa Münster - Gümbel, p. 135, pl. XIX, figs. 1a-e.

*. 1914 Gonioclymenia Kiliani sp. nov. - Wedekind, p. 61, pl. 6, fig. 4.

. 1923a Costaclymenia binodosa Münster - Schindewolf, p. 483.

. 1929 Costaclymenia binodosa Münster - Lange, p. 73, pl. 2, fig. 17.

p. 1981 Costaclymenia binodosa Münster - Bogoslovskiy, p. 45, pl. III, fig. 2.

Type material: The lectotype (proposed as the specimen figured by Wedekind 1914, pl. 6, fig. 4) collected by Wedekind from Dasberg, Sauerland, cannot be traced at the GPI Göttingen (Jahnke, pers. comm.), and is believed to be lost.

The holotype is poorly known and was placed originally in the genus Gonioclymenia (Wedekind 1914, p. 61). However, Wedekind did not observe a suture, and the growth-lines on the figured specimen are concave, unlike the S-shaped growth-lines of Gonioclymenia. Lange (1929, p. 73) believed that the species was conspecific with Costaclymenia binodosa.

Diagnosis: Endosiphonites (Costaclymenia) with ornament consisting of smooth inner whorls. Later tubercles develop on the ventro-lateral shoulder, which are replaced in mature examples by concave ribs.

Description: Four specimens were considered: Wedekind's figure, BSP AS VII 587 (Pl. 5.2, Figs. 8,9), 590 (Pl. 5.2, Figs. 3,6,7), SM H10385 (Pl. 5.2, Figs. 4,5). The inner whorls, visible on BSP AS VII 587 and SM H10385, are smooth with a rounded cross-section. Ventro-lateral tubercles are developed on BSP AS VII

587 by a diameter of ca 15mm, and on this specimen and SM H10385, gradually extend across the flanks to become concave, and then radial ribs, as the diameter increases and the whorl section becomes more quadrate and compressed. The ribs diminish in strength on the body chamber, and protrude less from the ventro-lateral shoulder on BSP AS VII 587, yet remain strongly developed on SM H10385. The partial sutural ontogeny is illustrated in Textfigs. 5.4D-F, from SM H10385.

Dimensions:

	D	U	WW	WH	R
Lectotype, Wedekind 1914, pl.6, fig.4, (assuming that the illustration is at natural size).	ca52	27	-	12.5	30
BSP AS VII 587	48.9	24.9	v.ca8	13.4	
	35.2	18.6	6.9	9.5	
BSP AS VII 590	60.8	29.4	11	19	ca35
	47.8	23.3	8.8	14.7	
SM H10385			13	18	38
			7.6	9.5	20
			5	3.2	11
			ca2	ca2.5	3.3

Remarks: The three species of <u>End</u>. (<u>Costaclymenia</u>) can be distinguished by their ribbing. <u>End</u>. (<u>Cost</u>.) <u>multicostata</u> has dense, weakly concave, prorsiradiate ribs. <u>End</u>. (<u>Cost</u>.) <u>binodosa</u> has long been interpreted as having straight or concave ribs and lacking pronounced tubercles, exemplified by Münster's 1839 figure. However, since strong ventro-lateral and umbilico-lateral tubercles are visible on Münster's earlier (1832) figure, this is the way in which <u>End</u>. (<u>Costaclymenia</u>) <u>binodosa</u> has been redefined here. <u>Gonioclymenia</u> <u>kiliani</u> Wedekind was recognised by Lange (1929) to be a <u>Costaclymenia</u>, and this is the only avaiable name for <u>End</u>. (<u>Costaclymenia</u>) <u>binodosa</u> <u>sensu</u> Münster 1839 and later authors. It is unfortunate that Wedekind's figured specimen has been mislaid, but his photograph of it is adequate enough for interpretation.

Brügge (1973) has recently studied a carefully collected sequence across the Platyclymenia/Clymenia Stufe boundary at Alte Heerstrasse near Schleiz, Thuringia. Here he recorded the incoming of Bispathodus costatus costatus (Branson 1934) (the index for the base of the costatus Zone) in Bed 35, occurring with species of Platyclymenia. Above this in Beds 28, 27, 26, 24, and 16 he recorded Costaclymenia binodosa. Of the two specimens he illustrated (MfN c429.6, Bed 26, pl. 1, fig. 5; c429.7, Bed 16, pl. 2, fig. 1) only the latter (Pl. 5.1, Fig. 11) seems to belong to this species. The former (Pl. 5.1, Figs. 9,10) is too small to be identified with certainty, but may be End. (Cost.) binodosa s.s. Both have smooth inner whorls and later develop spinose ventro-lateral tubercles and then a ribbed ornament. From the same beds Brügge recognised species of Kosmoclymenia and Clymenia, which are a confirmation of the position of this fauna in the Clymenia Stufe (but not the earliest Clymenia Stufe).

Horizon and distribution: The species is known from the Clymenia Stufe of the Rheinische Schiefergebirge, Oberfranken, southern Urals and Kazakhstan. Lange (1929, p. 26) made this species the index for his lowest Clymenia Stufe zone, Vα, but Wedekind stated that the type came from the upper Clymenia Stufe, Vβ, of Dasberg.

Family Biloclymeniidae Bogoslovskiy 1955

Type genus: Biloclymenia Schindewolf 1921
Diagnosis: Sellaclymeniaceae with subinvolute coiling, rounded venter lacking ornament, and with a suture ranging in complexity from comprising ventral, lateral and dorsal lobes, to subdivided ventral lobe, lateral umbilical and dorsal lobes.

Two subfamilies are recognised Pachyclymeniinae (proposed here) and Biloclymeniinae, the latter having a subdivided ventral lobe.

Subfamily Pachyclymeniinae nov.

Type genus: Pachyclymenia Schindewolf 1937a.
Diagnosis: Biloclymeniidae with simple suture consisting of ventral, lateral and dorsal lobes (Uraloclymenia), or an additional lobe (Pachyclymenia) (Textfig. 4.8I,J).

Included genera:

Uraloclymenia Bogoslovskiy 1977
Pachyclymenia Schindewolf 1937a

Remarks: No species are described here.

Horizon: Examples are known from the annulata Zone and the Clymenia Stufe. Uraloclymenia is known from the Urals and Kazakhstan (USSR) and Pachyclymenia from the Kellerwald (W. Germany), and from the southern Urals (USSR).

Subfamily Biloclymeniinae Bogoslovskiy 1955

Type genus: Biloclymenia Schindewolf 1921.
Diagnosis: Biloclymeniidae with subdivided ventral lobe.

Included genera:

Bilocylmenia	Schindewolf 1921
Gen. Nov. _C_	proposed here
Riphaeoclymenia	Bogoslovskiy 1981

Remarks: _Biloclymenia_ is not well known, and _Kiaclymenia_ Bogoslovskiy 1955 is considered to be a junior subjective synonym of it (see below). Gen. Nov. _C_, which has an extra umbilical lobe, is proposed as a replacement name for _Biloclymenia_ _sensu_ Bogoslovskiy, Schindewolf 1937a, non Schindewolf 1921, 1923. _Riphaeoclymenia_ described from only one specimen, appears simply to be an evolute _Biloclymenia_, and thus may deserve only subgeneric rank.

Horizon and distribution: Representatives of the subfamily (_Biloclymenia_, Gen. Nov. _C_) are known from the _Clymenia_ Stufe, Rheinische Schiefergebirge, Oberfranken (W. Germany), Thuringia (E. Germany), Urals, Kazakhstan (USSR), North Africa, Carnic Alps (Austria-Italy) and Cantabrian Mountains (Spain). _Riphaeoclymenia_ was recorded from the _Wocklumeria_ Stufe of the southern Urals.

Genus _Biloclymenia_ Schindewolf 1921

Type species: _Clymenia_ _laevis_ Richter 1848, by original designation (monotypy) of Schindewolf (1921, p. 167).
Diagnosis: Member of the Biloclymeniidae with an external suture consisting of a broad ventral saddle with a shallow ventro-lateral lobe on either side, and a lateral lobe (Textfig. 4.8C).

Description: Shell subinvolute with rounded flanks and venter. Growth-lines are S-shaped over the flanks and there is a sinus over the venter. The internal suture consists of an umbilical lobe and a dorsal lobe.

Included species:

*laevis	Richter 1848, p. 30, pl. III, figs. 81,2, Saalfeld, Thuringia.
adversa	Richter 1848, p. 29, pl. III, figs. 75,6, Saalfeld, Thuringia.
?bilobata	Münster 1839, p. 11, pl. II, figs. 6a-c, Schübelhammer, Oberfranken.
semiplicata	Bogoslovskiy 1981, p. 63, pl. VI, fig. 10, text-fig. 18c, Kiya River, Aktyubinsk Oblast', s. Urals.
sinuata	Richter 1848, p. 30, pl. III, figs. 79,80, Saalfeld, Thuringia.
uralica	Bogoslovskiy 1955, p. 136, figs. 1a-d, Kiya River, Aktyubinsk Oblast', s. Urals.

Remarks: Schindewolf considered that he had established this genus in 1923 (Schindewolf 1923a,b) with type species Cl. bilobata Münster, which he diagnosed (1923b, fig. 4d) as having a suture with the same elements as Biloclymenia laevis Richter, (see Text-fig. 4.8D). Schmidt (1923) reported briefly on the goniatites and clymeniids described by Richter (1848), and suggested that Cl. laevis was synonymous with Cymaclymenia obesa (Richter). In 1924 Schindewolf published a description of the ammonoid faunas of the Famennian of the Saalfeld region, whence Richter had derived his material. Here he stated that Biloclymenia laevis and bilobata could be distinguished from one another by their whorl cross-sectional shape: Bil. laevis was compressed with whorl height greater than whorl width, and Bil. bilobata was depressed with whorl height equal to whorl width. In the original description of Cl. laevis, however, Richter (1848, p. 30) states that "D = 1", (i.e. the ratio of whorl height to whorl width was equal to one). Too much attention should not be paid to this, except to point the apparent contradiction, since fossils from Saalfeld are strongly deformed (e.g. Richter 1848, pl. IV), and thus extremely difficult to interpret.

Later, Schindewolf (1937a) modified his ideas still further and using material from Beil (Balve) and Enkeberg, redefined <u>Biloclymenia</u> by its suture. The dimensions of the specimen or specimens on which the figures were based were not stated, nor can the relevant material be traced, but a mature suture (fig. 10) was shown consisting of a shallow secondary ventral lobe and ventro-lateral lobe, a lateral lobe, two umbilical lobes and a dorsal lobe (Textfig. 4.8B, 5.2I). Schindewolf assumed that this represented the adult suture of <u>Biloclymenia</u>, modified by the formation of an extra lobe at the umbilicus, and modification of the low ventral saddle by the addition of a secondary ventral lobe. He made no attempt here to discriminate between species of <u>Biloclymenia</u>, all figures were assigned to <u>Bil</u>. <u>bilobata</u>.

This interpretation of the ontogeny of the suture of <u>Biloclymenia</u> was contradicted by Bogoslovskiy (1955) who interpreted <u>Bil</u>. <u>bilobata</u> on the basis of Schindewolf's figure of the mature suture (1937a, fig. 10) and established a new monospecific genus, <u>Kiaclymenia</u>, for specimens with a suture similar to <u>Biloclymenia</u> <u>sensu</u> Schindewolf, 1923b (Textfig. 4.8C).

A satisfactory solution to this problem can as ever, only be found by looking at the original statements and figures. Firstly the establishment of <u>Biloclymenia</u> Schindewolf dates, not from the time of definition (1923) but from the time of first usage. This was in a faunal list (Schindewolf 1921, p. 167) and <u>laevis</u> Richter was the only included species. The justification for this decision can be found in the <u>Code</u>, Articles 12 and 16 (a)(v) which state (12) that "... a name published before 1931 must have been accompanied by a description, definition or indication (Art. 16)", and (16(a)(v)), "The word 'indication' includes 'the citation, in combination with a new genus group name, of one or more available specific names.'".

When interpreted this way the type species of Biloclymenia Schindewolf 1921 remains poorly known. Richter's illustration (1848, pl. III, figs. 81,2) and original material are poor, and Cl. laevis Richter may itself be a junior subjective synonym of Cl. adversa or Cl. sinuata, which were described earlier in the same text. Dr. D. Weyer (Magdeburg) has informed me that he has collected Biloclymenia from the type-area of Bohlen, seen Richter's material in the Zentrales Geologisches Institut (Bernau, outside Berlin) and that a revision is in progress.

Biloclymenia bilobata is considered in greater detail below. Briefly Münster's figure (1839, pl. II, figs. 6a-c) shows an external suture consisting of a broad, deep ventral lobe, a lateral lobe and an umbilical lobe, and thus it resembles neither Biloclymenia s.s. nor Biloclymenia sensu Schindewolf 1937. Schindewolf seems to have based his later interpretation of Bil. bilobata on Gümbel's figure (1863, pl. XIX, figs. 4) which he had claimed was Münster's original.

If we accept Bogoslovskiy's evidence that his suture drawing of Kiaclymenia (Biloclymenia s.s.) is based on a mature example, which is likely (WW = 13.6, WH = 13.7), then Kiaclymenia becomes a subjective synonym of Biloclymenia Schindewolf 1921 and Biloclymenia sensu Schindewolf 1937, fig. 10, with its additional lobes may deserve an independent generic name, since it is also based on a mature specimen, and is referred to here as Gen. Nov. C.

Horizon and distribution: The genus is known from the Sauerland, Oberfranken (W. Germany), Saalfeld (E. Germany), Carnic Alps (Austria-Italy), Cantabrian Mountains (Spain) and the southern Urals (USSR).

Biloclymenia bilobata (Münster 1839)

Pl. 5.11, Figs. 2,5,6, Textfigs. 5.2F-H

* 1839 Clymenia bilobata sp. nov. - Münster, p. 11, pl. II, figs. 6a-c.

1843 Clymenia bilobata Münster - Münster, p. 39, pl. II, figs. 6a-c.

non 1863 Clymenia bilobata Münster - Gümbel, p. 147, pl. XIX, figs. 4,5.

Type material: Two syntypes, BSP AS VII 524 and 525, have been traced but since these are both juveniles neither has been proposed as the lectotype. No new material has been collected and so the species is currently regarded as a nomen dubium.

Diagnosis: Biloclymenia, shown with compressed whorl section in Münster's figure.

Description: The two specimens from Schübelhammer, Oberfranken, housed in the BSP are used in this description.

The two syntypes are small (dimensions below). One (BSP AS VII 525) has been broken and polished to show the suture (Textfig. 5.2F), the other (BSP AS VII 524) shows no suture, and therefore may not belong to this genus. This second specimen (Pl. 5.11, Figs. 2,5,6, Textfig. 5.2G) however, has written upon it "C ii 6", which is taken as a reference to Münster's figure, and on this evidence it is regarded as a syntype. This figure (1839, pl. II, figs. 6a-c) shows a subinvolute ammonoid (dimensions below) with a compressed whorl section, and a broad rounded venter. The description (p. 11) made no reference to ornament and none is visible in the figure. The external suture (fig. 6c) comprised two lateral lobes and a broad lobe over the venter.

A cross-section of BSP AS VII 525 is illustrated here (Textfig. 5.2H) along with the suture. Its course over the umbilicus is not clear since the wall has been broken away. The other remaining syntype BSP AS VII 524, is illustrated in Pl. 5.11, figs. 2,5,6, but the photographs reveal little apart from the gross morphology, a ventral keel (part of the wrinkle-layer), weak umbilical ribs, growth-lines which are S-shaped, and swing forwards strongly over the ventro-lateral shoulder.

Dimensions: see Biloclymenia sp. below.

Remarks: This species is no longer regarded as the type of Biloclymenia. No other material from the type area has been traced, either in museums or by recent collecting, and so instead of resurrecting this species by choosing a neotype, it will be allowed to fall into disuse, and be regarded as a nomen dubium, since in the absence of suitable type material it can never be accurately defined. The dimensions of the specimens figured by Münster and Richter as Cl. bilobata and Cl. laevis seem similar, but these are taken from the original drawings and are not considered sufficient to place the two species in synonymy.

Horizon and distribution: All known specimens were collected from Schübelhammer, Oberfranken, and are presumed to be from the Clymenia Stufe.

Biloclymenia sp. a

Pl. 5.11, Figs. 7-10, Textfigs. 5.2J-L

Material: Three specimens from the Sauerland, two of which are housed in the MfN (one being figured by Schindewolf 1937a, pl. 1, fig. 10), and another, KW 2091, from Kasberg, Langenholthausen (Balve) in the collection of Dr. K. Wunderlich.

Description: The three specimens are illustrated in Pl. 5.11 (Figs. 7-10). The best preserved is KW 2091 (Figs. 7-10).

The subinvolute coiling and rounded cross-sectional shape can be see in Textfig. 5.2L. Growth-lines are not preserved on the dorsad part of the flanks, but are probably biconvex. There is a salient over the ventro-lateral shoulder and a broad sinus over the venter (Fig. 7), where there are shallow grooves, parallel with the growth-lines. Such grooves are also visible near the umbilico-lateral shoulder (Fig. 10). Also visible on Fig. 10 are small tubular structures which are the tests of cemented arenaceous Foraminifera. The wrinkle-layer, a series of radial, slightly sinuous ridges appears to cover the attached Foraminifera, as it does also a part of the cemented pedicle valve of a disciniscid brachiopod. This suggests that both the Foraminifera and the brachiopod attached themselves during the life of the ammonoid, and were subsequently sealed in when the next whorl of the ammonoid reached that point.

The body chamber was at least 360° in length. The external suture (Fig. 9, Textfig. 5.2J,K) consists of a lateral lobe and an umbilical lobe only, and there is no subdivision of the broad ventral saddle, even at a whorl height of 20mm.

Figure 1 is of a specimen from Beil which shows growth-lines which are concavo-convex rather than biconvex, and has faint plicate ribs on the flanks near the umbilical shoulder. The specimen in Figs. 3 and 4 is illustrated simply to show the morphology of the specimen which was sectioned by Schindewolf (1937a, pl. 1, fig. 10) to show the nature of the siphuncle. This has a diameter which varies between 15 and 25% of the whorl height, between diameters of 15 and 27mm. The septal necks run into one another to form a continuous tube.

Dimensions:

	D	U	WW	WH	AH
2091	69	14.7	20.2	31	19.6
	45.4	8.9	18.5	20.0	13.0
	32.5	6.5	12.4	15.6	9.9
	15.9	3.1	7.1	7.4	5.0
	7.6	1.2	3.7	3.5	2.5
bilobata sensu auctt.	34.5	6.1	6.9	17.3	10.3
MfN = Schindewolf 1937a, fig.10.	26.2	5.0	6.1	13	-
Münster 1839, pl.II fig.6.	26.3	6.0	10.5	13	8.5
Gümbel 1863, pl.XIX fig.4	25.2	7.5	11	12	7
Richter 1848, pl.III fig.81.	20	4	8.5	8.5	
BSP AS VII 524	11.1	3.8	5.5	4.35	
BSP AS VII 525			4	3.5	

Remarks: The conclusions of the discussion of _Biloclymenia_ so far have been its diagnosis without further comment on the type species, for lack of information, and an inconclusive description of _Bil_. _bilobata_. This suggests that the genus is only poorly known, yet this would be a false impression since authors have provided good descriptions and illustrations (Petter 1960, Kullmann 1960, Bogoslovskiy 1981).

Horizon and distribution: The age of these specimens cannot be stated with certainty. Only the lower part of the _Clymenia_ Stufe has been proved at Beil, and the specimen from Langenholthausen was found in association with _Kosmoclymenia_ and is considered to be from the middle _Clymenia_ Stufe. There is no evidence of the age of the specimen from Enkeberg.

Family Wocklumeriidae Schindewolf 1937

Type genus: Wocklumeria Wedekind 1917

Diagnosis: Sellaclymeniaceae with constricted globose shell form and triangular coiling in early whorls, at least. Suture comprising ventral, lateral, three umbilical and dorsal lobes.

Included genera:

Wocklumeria	Wedekind 1917
Epiwocklumeria	Schindewolf 1937a
?Synwocklumeria	Librovich 1957

Remarks: It is not apparent to me how Bogoslovskiy (1981) distinguishes Epiwocklumeria and Synwocklumeria. They appear to be homeomorphic yet he suggests that their similar sutures are derived in different ways, i.e. Epiwocklumeria "$VUU^1:U^1ID$", Synwocklumeria "$VUU^1:U^2ID$" (Textfig. 4.8E,F), but he provided no sutural ontogenies to substantiate his opinion.

Horizon and distribution: This distinctive family is known only from the sphaeroides Subzone of England, Brittany, Rheinische Schiefergebirge, Thuringia, Poland, Carnic Alps (Austria-Italy), Montagne Noire, Urals, Caucasus (USSR) and North Africa.

Superfamily Parawocklumeriaceae Schindewolf 1937

Family Parawocklumeriidae Schindewolf 1937

Diagnosis: Gonioclymeniina in which ventral and dorsal lobes either become divided during ontogeny, or replaced by saddles.

One family is recognised, Parawocklumeriidae, containing three genera:

- *Parawocklumeria* Schindewolf 1926
- *Kamptoclymenia* Schindewolf 1937a
- *Triaclymenia* Schindewolf 1937a

Remarks: The typical globose, triangular shell form of this family resembles that of Wocklumeriidae, which can be found in the same stratigraphic horizons. Fundamental differences in sutural pattern distinguish these homeomorphic groups (see Chapter 4). No examples are described here.

Horizon and distribution: Representatives are widely known from the *paradoxa* Zone of England, Brittany, Germany, Poland, Urals, Carnic Alps, Montagne Noire, and south western China.

Superfamily Gonioclymeniaceae Hyatt 1884

Only one family is recognised, the Gonioclymeniidae.

Family Gonioclymeniidae Hyatt 1884

Diagnosis: Gonioclymeniina with suture comprising ventral, adventive, lateral, umbilical and internal lobes, which elaborate by addition of further adventive and umbilical lobes. Shell form is discoidal, coiling evolute, with compressed whorl section.

Two subfamilies are recognised: Gonioclymeniinae and Sphenoclymeniinae.

Horizon and distribution: Representatives are known from the _Clymenia_ and _Wocklumeria_ Stufen of England, Germany, Poland, Urals, Caucasus (USSR), North Africa, Carnic Alps and Montagne Noire (France).

Subfamily Gonioclymeniinae Hyatt 1884

Type genus: _Gonioclymenia_ Hyatt 1884.
Diagnosis: Gonioclymeniidae with stable sutural composition comprising ventral, adventitious (= ventro-lateral), lateral, umbilical and dorsal lobes.

Description: Coiling is evolute, shell form discoidal and whorl section compressed. Growth-lines are S-shaped with a ventral sinus. Ribs are common and tubercles or spines are developed in some cases. Septa are concave in sagittal-section, and septal necks long and contiguous.

Included genera:

<u>Gonioclymenia</u> (<u>Gonioclymenia</u>) Hyatt 1884
<u>Gonioclymenia</u> (<u>Kalloclymenia</u>) Wedekind 1914
<u>Gonioclymenia</u> (Subgen. Nov. <u>A</u>) proposed here
<u>Gonioclymenia</u> (Subgen. Nov. <u>B</u>) proposed here

Remarks: <u>Otoclymenia</u> Schindewolf 1923a is regarded as a synonym of <u>Kalloclymenia</u> Wedekind 1914. Two new subgenera are proposed here and are discussed below.

Münster described many species which can now be recognised as belonging to the Gonioclymeniinae. Many were distinguished by trivial differences in sutural shape or ribbing. Unfortunately they were poorly illustrated and good type material is lacking, so that most of these names must be regarded as <u>nomina</u> <u>dubia</u>.

All of the available Münster species names are listed below, and, where possible they are assigned to a subgenus:

<u>arquatus</u>,	? Münster 1839, p. 27, pl. XVIII, fig. 4; later (1840, p. 110) as <u>arcuatus</u>, Schübelhammer, Oberfranken.
<u>angustus</u>,	? Subgen. Nov. <u>A</u>. Münster 1839, p. 28, Schübelhammer, Oberfranken.
<u>bucklandii</u>,	? Münster 1839, p. 26, pl. XVIII, fig. 5, Schübelhammer, Oberfranken.
<u>canalifer</u>,	<u>Gonioclymenia</u>. Münster 1839, p. 26, pl. XVIII, fig. 2, Schübelhammer, Oberfranken.
<u>clymeniaeformis</u>,	? Subgen. Nov. <u>A</u>. Münster 1839, p. 24, pl. XVII, figs. 4a-c, Gattendorf, Oberfranken.
<u>cottai</u>,	<u>Gonioclymenia</u>. Münster 1839, p. 25, Schübelhammer, Oberfranken.
<u>preslii</u>,	<u>Gonioclymenia</u>. Münster 1839, p. 24, pl. XVII, figs. 3a-c, Schübelhammer, Oberfranken.
<u>roemeri</u>,	<u>Gonioclymenia</u>. Münster 1839, p. 27, pl. XVIII, fig. 3, Schübelhammer, Oberfranken.
<u>speciosa</u>,	<u>Gonioclymenia</u>. Münster 1831a, p. 177, Heinersreuth (= Schübelhammer ?) Oberfranken.

subarmata, Kalloclymenia. Münster 1832, p. 28, pl. VI, figs. 2a-c, Schübelhammer, Oberfranken.

subcarinata, Gonioclymenia. Münster 1839, p. 25, pl. XVIII, figs. 1a-c, Schübelhammer, Oberfranken.

spuria, Gonioclymenia. Münster 1832, p. 30, Elbersreuth and Schübelhammer, Oberfranken.

Because some of these names cannot be assigned to particular genera they will all be discussed here. Gonioclymenia speciosa, Gon. subcarinata and Kall. subarmata are the only Münster names to have achieved universal usage in the literature. Frech (1902, p. 39) used Gon. plana Münster and listed Gon. subcarinata, preslii and canalifer as being synonymous with it, basing his views on material in the Museum für Naturkunde in Berlin. Wedekind re-examined the Berlin material and gave a description (1914, p. 62) of Gon. plana which agreed with Münster's description and he made Gon. plana sensu Frech a synonym of either Gon. speciosa or subcarinata. Schmidt (1921) later used the name Gon. plana but this species belongs to the genus Sellaclymenia, which was pointed out by Schindewolf (1923a). Schmidt also used the names Gon. cottai and Gon. interrupta (1921, p. 332,333). He regarded Gonioclymenia cottai to be a variety of speciosa, and he distinguished it from other species of Gonioclymenia by its flattened sides, deeper ventral groove and closely packed sickle-shaped ribs, numbering 36 in the whorl prior to a diameter of 25mm. Adding to this description (1924, p. 139) he said that the variety had sickle-shaped growth-lines with the convex part being more forwardly curved than in the normal type. Münster had described (1839, p. 25) the species as similar in size and suture to G. preslii, but with more closely spaced ribs. The description of G. preslii was based on an example two inches in diameter (1839, p. 24). Therefore the small specimen (BSP) which was figured by

Gümbel as Münster's original (1863, pl. XIX, figs. 8a-d) is clearly not Münster's type specimen, and since Münster did not figure an example the name cannot with certainty ever be assigned to a particular specific description. Furthermore Gümbel's figure (1863, pl. XIX, figs. 8a-d) of this specimen shows the ribs to be more densely spaced than they actually are (see Pl. 5.4, Fig. 3).

Schmidt's use of the name Gon. interrupta is also of questionable value. No specimens collected by Münster can be examined today, nor did Schmidt state that his usage of the name was based on an examination of any type material. Münster's description and figure of Cl. interrupta (1842, p. 126, pl. XII, figs. 3a-b) show a flatly discoidal ammonoid with falcate growth-lines, every fifth or sixth one being raised to form a rib, of which there are 11 - 12 in early whorls, but ca 20 in the whorl preceding a diameter of 40mm. The ribs and growth-lines form a sinus over the venter which is bounded by a pair of longitudinal grooves, similar to those at present in the species Kosmoclymenia bisulcata (Münster). This latter feature precludes the species, sensu Münster, from being a Gonioclymenia since it has no median ventral groove. Unfortunately Münster did not figure a suture and even though his figure is relatively detailed it is not possible at present to equate this with a particular species, nor even assign it to a genus. Schmidt distinguished his species interrupta on the basis of spines developed on the ventro-lateral shoulder, present up to a diameter of at least 25mm. I have been unable to trace Schmidt's specimen in Berlin but it is likely that it is related to Subgen. Nov. B brevispina (Lange). Czarnocki (in Miller and Zwierz, 1970) also used the name Kall. interrupta presumably in the same sense as Schmidt, as did Bogoslovskiy (1981).

A digression is necessary here to discuss the names introduced by Czarnocki, who between 1909 and the Second World War published a series of papers (see Rühle 1972, p. 120-1) on the stratigraphy and the palaeontology of the Devonian and Carboniferous of the Holy Cross Mountains of Poland. He prepared, but never published, a monograph on the ammonoid faunas of the Upper Famennian in which he intended to introduce at least 16 new generic and 131 new specific names. His museum labels appear to have been used in a catalogue of the Palaeozoic fossils deposited in the Geological Institute in Warsaw (Miller and Zwierz 1970). These names were subsequently given wider publication in a catalogue of fossils forming part of the series, Geology of Poland (Rühle 1972). Thus all of Czarnocki's taxonomic names were introduced to the literature without description, and are *nomina nuda*.

There are remaining in Munich, Berlin and Cambridge examples of the species *G. arquatus* (1839, p. 27) and *G. canalifer* (1839, p. 24, pl. XVII, figs. 3a-c). None can be well described because of the state of the preservation of the material. Münster distinguished his species *G. arquatus* by its suture, which had angular lobes and saddles, with the exception of the ventral lobe which was shallow. An unnumbered specimen in Munich which is labelled as *G. arquatus* has a suture like *Sphenoclymenia maxima* and therefore cannot be the specimen Münster figured. Münster's description of the species is unlike that of any other *Gonioclymenia*. They all have deep, pointed ventral lobes, unless there is material missing from the venter, (which is a possible explanation in this case) although *Kall. subarmata* has a wide ventral lobe (Textfig. 5.9A). Schmidt (1921, p. 332, textfig. 7c) figured the suture of *Kall. biimpressa* (von Buch), which had similar proportions, but he later (1924, p. 139) changed this identification to Kall. subarmata (Münster).

Three extant specimens labelled as G. canalifer in Berlin (unnumbered), Munich (unnumbered) and Cambridge (SM H10408), although well preserved, are similarly of little diagnostic use. Münster's description (1839, p. 26) was based on a large example. This is shown by the size of the suture that he figured (1839, pl. XVIII, fig. 2). He distinguished the species by its straight, prorsiradiate ribs and its grooved venter.

There is one unnumbered specimen of the species G. preslii (Münster 1839, p. 24, pl. XVIII, figs. 3a-c) remaining in Munich. This is highly weathered and bears little resemblance to Münster's figure, which showed a compressed high whorl section and straight radial ribs. Frech figured an apertural view of a specimen from Berlin under the name Gon. plana (Münster), but identified it as an original of G. preslii Münster (1902, p. 39, pl. II(I), fig. 4b, textfig. $6b_{1-4}$ (p. 38)). Gümbel's figure of Münster's original differs from Münster's figure by having falcate, not straight ribs, at a diameter of 35mm, and a whorl cross-section which is more depressed with converging flanks and a deep ventral groove, in contrast to the compressed whorl section with parallel flanks and shallow ventral groove in the original figure. Münster's figure of G. preslii (pl. XVIII, fig. 3c) has a suture with rounded lobes and saddles, which shows it to be an immature form. Frech's figure of the suture (?1897, p. 177k, textfig. $6b_{1-4}$, and 1902, supra cit.) from a larger specimen, is also of little use in more accurately diagnosing the species.

Münster described a species G. spurius (1832, p. 30) which he did not figure. This, he said, had the shell shape of G. speciosus, the suture of G. subarmatus and the ornament of G.

planus. One specimen exists in the Sedgwick Museum, Cambridge, but this (SM H10408) is badly weathered and cannot be the basis for a detailed description, save to say that it is a species of *Gonioclymenia*. Münster's description is closest to *Gonioclymenia subcostulata* Petter.

There were other species, which, from Münster's scant descriptions, appear to be gonioclymeniids. They were distinguished by him on the basis of their suture, a characteristic which shows more variability within a specimen during its growth, than between species at similar dimensions. These distinctions are therefore largely invalid. Two species are not represented by existing specimens: *G. Bucklandii* (1839, p. 28, pl. XVIII, fig. 5) and *G. Roemeri* (1839, p. 27, pl. XVIII, fig. 3).

Genus *Gonioclymenia* Hyatt 1884

Type species: *Goniatites speciosus* Münster 1831, by original designation of Hyatt.
Diagnosis: Gonioclymeniidae with a suture consisting of a ventral lobe, three lateral lobes, and a dorsal lobe, all of which are pointed.

Description: See the separate subgenera below.

Horizon and distribution: As for Gonioclymeniinae.

Subgenus *Gonioclymenia* (*Gonioclymenia*) Hyatt 1884

Type species: *Goniatites speciosus* Münster 1831, by original designation of Hyatt (1884, p. 314).
Diagnosis: *Gonioclymenia* with a grooved venter.

Description: Evolute with compressed whorl section and converging flanks. Early whorls with an ornament consisting of spines on the ventro-lateral shoulders, developing into ribs, which later disappear, on the body chamber. A ventral groove is present on the phragmocone but may disappear on the mature body chamber. Growth-lines are S-shaped over the flank with a ventral sinus. Maximum size is large for clymeniids, attaining a diameter of 30 centimetres.

Available species names include:

*speciosa	Münster 1831, p. 177, Heinersreuth, Oberfranken.
?corpulenta	Bogoslovskiy 1981, p. 85, pl. XIV, figs. 1a,b, textfig. 36b, Kiya River, Akt. Oblast'.
hoevelensis	Wedekind 1914, p. 58, pl. 6, figs. 2a-b, pl. 5, fig. 7, Hövel, Sauerland.
kiensis	Bogoslovskiy 1981, p. 82, pl. IX, figs. 2a,b, textfig. 34, Kiya River, Akt. Oblast'.
levis	Bogoslovskiy 1981, p. 83, pl. X, figs. 1,2, textfig. 35, Kiya River, Akt. Oblast'.
praematura	Wedekind 1914, pl. 6, figs. 6a-c, Hövel, Sauerland.
subcarinata	Münster 1839, p. 25, pl. XVIII, figs. 1a-c, Schübelhammer, Oberfranken.
subcostulata	Petter 1960, p. 14, pl. 1, figs. 1a,6a,12a, textfigs. $2E_1$, Kreb oued Amerloh, Tafilalet, Algeria.
tornquisti	Wedekind 1914, p. 64, pl. 5, fig. 4a-b, pl. 6, fig. 7, pl. 7, fig.2, Hövel, Sauerland.

Remarks: Only two Münster species are recognised, Gon. subcarinata and Gon. speciosa. Species have been established by other authors, such as Gon. praematura, tornquisti and hoevelensis Wedekind but these are based on minor differences in ribbing and sutural form observed on only few specimens. These cannot be recognised as useful species until more specimens have been collected and studied. Descriptions of the types of these species can be found in Wedekind 1914, and they are amplified below in cases where type material was available. Yet more species established by Wedekind (1914) are now recognised as belonging to other genera, namely Sellaclymenia torleyi, Costaclymenia (Cost.) kiliani and Gon. (Kalloclymenia) crassa. Münster was responsible for naming many species subsequently included within Gonioclymenia. These have already been discussed (see above, Gonioclymeniinae).

Horizon and distribution: This subgenus is known from the Clymenia Stufe of Launceston (England), Cantabrian Mountains (Spain), Montagne Noire (France), Carnic Alps (Austria-Italy), Oberfranken, Rheinische Schiefergebirge (W. Germany), Thuringia, Sächische, Vögtland (E. Germany), Holy Cross Mountains (Poland) and the southern Urals (USSR).

Gonioclymenia (Gonioclymenia) speciosa (Münster 1831)

Pl. 5.3, Figs. 1,3,4,7-9, Pl. 5.4, Figs. 1,8, Textfigs. 5.7A,B.

*	1831	Goniatites speciosus sp. nov. - Münster, p. 177.
	1832	Ammonites speciosus Münster - von Buch, p. 180, pl. II fig.,7.
v?	1832	Goniatites speciosus Münster - Münster, p. 27, pl. VI, figs. 1a-c.
	1834b	Goniatites speciosus Münster - Münster, p. 90, pl. V, figs. 5a-c, (French translation of Münster 1832).
v	1839	Goniatites speciosus Münster - Münster, p. 27, pl. XVIII, figs. 6.
non	1839	Clymenia speciosa sp. nov. - Münster, p. 7.
	1843	Goniatites speciosus Münster - Münster, p. 21, pl. VIa, figs. 1a-c, (copy of Münster 1832), p. 53, pl. XVIII, fig. 6, (copy of Munster 1839).
vp	1863	Clymenia speciosa Münster - Gümbel, p. 151, pl. XIX, figs. 6a-d, pl. XX, fig. 3.
pv	1923a	Gonioclymenia speciosa Münster - Schindewolf, p. 487.

Type material: BSP (unnumbered) is designated herein as the lectotype, and figured here, Pl. 5.3, figs. 7,8. This is believed to be the specimen figured by Münster 1832, pl. VI, figs. 1a-e.
Diagnosis: Gonioclymenia with a deep pointed ventro-lateral lobe, of about one half the depth of the midflank lateral lobe, and strong ribbing on the phragmocone.

Description: Three specimens from the Münster collection in Munich have been used to form this description: the lectotype, AS VII 595, which was the specimen figured by Münster (1839, pl. XVIII, fig. 6), and later by Gümbel (1863, pl. XX, figs. 3a-b), and AS VII 538, which was the specimen figured (embellished) by Gümbel, (1863, pl. XIX, figs. 6a-c).

The inner whorls of the lectotype (Pl. 5.3, Fig. 8) are not preserved, nor is a suture visible. Closely spaced radial or prorsiradiate, slightly sinuous ribs appear at a diameter of ca 20mm. There are ca 36 in the whorl prior to a diameter of 80mm (i.e. 1¼ whorls after ribs are first visible). The last whorl preserved is, apparently, smooth and the flanks converge to flattened venter, which has a very shallow median groove.

The second specimen that Münster figured, AS VII 595, (Pl. 5.3, Figs. 1,9) is remarkably preserved, in that it appears to show a series of interpenetrating funnel-shaped dorsal lobes, which would have totally enclosed the siphuncle. Ribbing, and a polished suture typical of the species are visible.

The internal whorls of Gümbel's figure (1863, pl. XIX, fig. 6a) are drawn in, because the specimen BSP AS VII 538, on which it appears to be based is strongly weathered up to a diameter of 50mm. A small tubercle on the ventro-lateral shoulder is visible at a whorl height of 6.3mm, and the ribs are not yet present. By a diameter of 55mm the rib internal moulds are straight, and by 70mm the ribs are slightly convex, radial and sinuous. In this respect they differ from the straighter, prorsiradiate ribs of the lectotype. Minor inter-rib ribs are developed on the dorsad half of the flanks, becoming less prominent as the major ribs spacing increases at a diameter of 80mm, although spacing varies within this interval. They are restricted to the flanks.

The whorl cross-section at the maximum diameter preserved (ca 110mm) is narrower and the flanks less converging than figured by Gümbel (1863, pl. XIV, fig. 6b). A ventral groove is clearly visible between a diameter of 45mm (Pl. 5.3, Fig. 4) and 85mm but this becomes shallow, and barely visible on the venter, although the ventral area is polished or damaged.

The suture, at a whorl height of 6.3mm, has rounded elements, a shallow ventro-lateral lobe, and a tongue-shaped, deep mid flank lobe resembling that of Kalloclymenia. At larger diameters the lobes and saddles became heightened and more angular, and the ventro-lateral lobe migrates dorsad across the flanks (Textfig. 5.7A,B).

Dimensions:

	D	U	WW	WH
Lectotype, BSP	150	ca62	vca38	51.5
Pl.5.3,Figs.7,8	114	44.1	25	42.1
BSP AS VII 538	107.7	45.5	ca22	ca38
	83.2	37.4	16.5	27.5

Remarks: This species was first mentioned by Münster in a general paper (1831, p. 177) on the occurrence of ammonites in thefossil record: "Dans le calcaire intermediare de Heinersreuth il y à un grand goniatite, que j'ai appelé Goniatites speciosus". This ammonite was Ammonites conybeari =(Vermiceras conybeari (Sowerby 1816, p. 70, pl. 131) according to D. T. Donovan) which is similar to Gon. speciosa in as far as it is large, evolute and ribbed, but it also has a keel, approximately equal whorl width and height and concave ribs which curve forwards over the venter, and therefore bears little close resemblance to the specimens which Münster subsequently figured as <u>speciosa</u>. Nevertheless this specific description probably falls within the scope of Article 12 of the <u>Code</u> (p. 13) which says that "a name published before 1931, must have been accompanied by a description, definition or indication". "Indication" is explicitly defined in Article 16(a) (i) - (viii) (<u>Code</u> p. 15) and Münster's wording certainly does not fall within any of the noted categories. However, Münster's definition was probably adequate by the standards of his day, and 1831 is interpreted as the valid date of <u>Gonioclymenia</u> <u>speciosa</u>.

In the same year that Münster described <u>G</u>. <u>speciosus</u> fully, with a figure (1832, p. 27, pl. VI, figs. 1a-c), Leopold von Buch also published a description of it, but acknowledged Münster as the author (1832, p. 180, pl. II, fig. 7). It has been common practice of authors (e.g. Schindewolf 1923a, 1957) to cite Münster 1832 as the bibliographic reference for this species, but it is likely that von Buch's description was published before Münster's since only Münster gives a specific page reference to the other's work. This implies that as he wrote he had von Buch's work in front of him. Wedekind seems to have been aware of the dilemma of which author had priority, and referred the species to both Münster and von Buch (1914, p. 62,3). Münster revised his account of the species in 1839 (p. 28, pl. XVIII, fig. 6). <u>Clymenia</u> <u>speciosa</u> Münster 1839 (p. 7) is an undescribed variety of <u>Cl</u>. <u>laevigata</u>, distinguished by Münster from other species of <u>Clymenia</u> by its large size. Beyrich (1859) first recognised that this species was a clymeniid and not a goniatite.

<u>Gonioclymenia</u> (<u>Gon</u>.) <u>subcostulata</u> Petter (1960, p. 14, pl. 1 figs. 1,a, 6,a, 12,a; textfigs. $2E_1$; lectotype proposed herein

as the specimen in pl. 1, figs. 1,a) has an ornament consisting of closely packed, shallow ribs (numbering approximately 100 in the whorl prior to a diameter of 60mm), and converging flanks.

Horizon and distrbution: The type locality was given by Münster (1831) as Heinersreuth, and this may be a mere reference to Schübelhammer only a few kilometres away, from which came most of the other clymeniids he later described (Münster 1832). The species is known from Oberfranken, Rheinische Schiefergebirge, Montagne Noire, Carnic Alps and the southern Urals. It is considered to come from the Clymenia Stufe.

Gonioclymenia (Gonioclymenia) subcarinata (Münster 1839)

Pl. 5.3, Figs. 5,6, Pl. 5.7, Fig. 3, Textfig. 5.7C,D.

v*	1839	Goniatites subcarinatus sp. nov. - Münster, p. 25, pl. XVIII, figs. 1a-c.
v	1843	Goniatites subcarinatus Münster - Münster, p. 50, pl. XVIII, figs. 1a-c, (copy of Münster 1839).
pv	1863	Clymenia speciosa Münster - Gümbel, p. 151, pl. XX, figs. 1a-c.
	1914	Gonioclymenia subcarinata Münster - Wedekind, p. 63.
vp	1923a	Gonioclymenia subcarinata Münster - Schindewolf, p. 489, textfig. 21b.
	1929	Gonioclymenia subcarinata Münster - Lange, p. 76.
	1960	Gonioclymenia subcarinata Münster - Petter, p. 13, pl. 1, figs. 2,a, 3,b, pl. II, figs. 4,a, 5,b, textfig. 2D.

Type material: The only specimen remaining in the BSP in Munich is AS VII 596, which proposed as the lectotype.

This specimen was figured by Gümbel (1863, pl. XX, figs. 1a-c) and is refigured here (Pl. 5.2, Figs. 5,6). Gümbel's figure is a detailed representation of it with little embellishment.

Münster's original figure (1839, pl. XVIII, figs. 1a-c) has exactly the same dimensions and is probably a representation of the same specimen.

Diagnosis: Gonioclymenia with a shallow ventro-lateral lobe.

Description: Only one specimen, the lectotype, BSP AS VII 556, has been seen, and this is figured in Pl. 5.3, Figs. 5,6 and Textfig. 5.7, and described below. Another specimen, SM H10409, figured here in Pl. 5.3, Fig. 2, may belong to this species, and on this the inner whorls are visible. The species greatly resembles Gonioclymenia (Gon.) speciosa. Gross morphology is exactly similar but the lectotype is well preserved and thus the inner whorls can be described, but not compared with Gon. (Gon.) speciosa, since they are not known for this species.

The inner whorls up to a diameter of ca 10mm appear to have a rounded whorl section, and an ornament consisting of ventro-lateral tubercles. Thereafter the flanks are flattened, the whorl section compressed and slightly S-shaped, prorsiradiate ribs develop across the flanks from the ventro-lateral tubercles. The tubercles themselves disappear after a diameter of ca 35mm, and the ribs become less prominent, being more widely spaced, broad and plicate after a diameter of ca 70mm. At the greatest diameter seen (110mm), which on the lectotype is still phragmocone, there seem to be no ribs, although at this stage the specimen has suffered from weathering. Between a diameter of 50mm and 80mm the venter is grooved, and in it runs a string-like keel (pl. 5.3, Fig. 5). The flanks at a maximum diameter of ca 110mm, although weathered appear slightly rounded and converging. The suture is illustrated in Textfig. 5.7C.

Dimensions

	D	U	WW	WH	A
Lectotype, AS VII 596	109	46	ca25.5	40.8	
RE 551,734.5. A256, lectotype of Gon. (Gon.) subcarinata praematura	108 78	39.5 43.5	27.3 22	40.7 29.5	36
BM 81839b, Pl.5.4, Fig. 4.			9.6	18	

Remarks: According to Münster (1831) the distinctive features of the species was the presence, in all but the last whorl, of a strong keel in the ventral groove. This keel can be seen in many clymeniids and is laid down on the venter of preceding whorls beneath the wrinkle-layer, as the animal secreted the floor of its new body chamber. Wedekind and subsequent authors have distinguished the species by its shallow rounded ventro-lateral lobe (Textfig. 5.7C) in contrast to the deeper, angular lobe to be seen on Gon. (Gon.) speciosa, otherwise their morphology is similar. The inner whorls of Gon. speciosa are unknown. Gonioclymenia (Gon.) subcarinata has a spinose ventro-lateral ornament on the earliest whorls, and then ribs develop (Pl. 5.3, Fig. 2).

Wedekind recognised a variety praematura (1914, p. 63), which had curved flanks and an acute saddle (Textfig. 5.7D) between the ventro-lateral lobe and the lateral lobe, in contrast to the rounded saddle in subcarinata. The difference in angularity may be caused by polishing on the lectotype. A further species, Gon. (Gon.) tournquisti (1914, p. 64), was recognised by Wedekind on the basis of a broad and rounded saddle between the ventro-lateral and first lobes, which in Gon. (Gon.) subcarinata was alleged to be smaller. Lange (1929, p. 76,77) united these two forms as varieties of Gon. (Gon.) subcarinata and dismissed the sutural differences as unfounded, distinguishing subcarinata tournquisti by its weak sculpture and Gon. (Gon.) subcarinata praematura by its curved flanks. The lectotype of Gon. (Gon.) subcarinata appears to have curved flanks itself at a diameter of 110mm.

The lectotype (proposed herein) of Gon. (Gon.) subcarinata praematura (Pl. 5.4, Figs. 5-7, RE 551.734.5 A256) has only a shallow groove on the venter of the body chamber at a diameter of ca 100mm. Grooves are visible on the internal mould of the body chamber at the same diameter presumably these were caused by raised structures on the internal side of the shell. They appear to follow the same course as the growth-lines. Wedekind used Gümbel's figure of the apertural shape of Gon. (Gon.) subcarinata (1863, pl. XX, fig. 1b), which showed converging, flat to concave flanks to define the whorl section shape in that species. Gümbel's figure was a conjectural reconstruction (see the actual apertural shape, Pl. 5.3, Fig. 5) and thus one of Wedekind's and Lange's criteria for subspecies diagnosis has no foundation.

Wedekind figured two specimens of Gon. tournquisti (1914, pl. 5, fig. 4, pl. 6, fig. 7, pl. 7, fig. 2) and the specimen in pl. 5, fig. 4 is proposed as the lectotype, since it was from this specimen that Wedekind figured the suture. (M. R. House has kindly provided photographs of these and other specimens figured by Wedekind (1914), now housed in the GPI, Göttingen.) Wedekind stated (1914, p. 64) that the sculpture on this species was weaker at middle sizes than in Gon. (Gon.) subcarinata. Ribbing density has been calculated on various specimens:

	Number of ribs in half whorl prior to diameter of ca 40mm.
Gon. (Gon.) subcarinata, lectotype	ca 12
Wedekind 1914, pl.6, fig.5	ca 14
Gon. (Gon.) praematura, lectotype.	ca 13

Gon. (Gon.) tournquisti, lectotype.	ca 8
Wedekind 1914, pl.7, fig.2.	ca 12

There seems to be a correlation between the frequency of ribs and their shape. Where there are few ribs they are broad, whereas closely packed ribs are narrow. Therefore the term weak sculpture, as used by Wedekind, can be taken to describe both rib frequency and strength. At present there is very little evidence concerning the ribbing strength of any species of (Gon.) Gonioclymenia, although Lange (1929, p. 77) stated that it was variable. Therefore, I do not accept the distinctions in ornament drawn between Gon. (Gon.) subcarinata, praematura or tournquisti as valid for for the purposes of defining subspecies.

Wedekind distinguished another species, Gonioclymenia hoevelensis (1914, p. 60, pl. 5, fig. 7, pl. 6, fig. 2) which has a subcarinata-type suture. The specimen figured in the former of these is designated as the lectotype. The species was used as the index for Schmidt's lower Clymenia Stufe zone, Vα. The diagnostic characteristic of this species was, according to Wedekind, the presence of paired ribs, joined at the ventro-lateral shoulder by a tubercle. Wedekind's description and figure (pl. 6, fig. 2) of a narrow whorl cross-section with parallel flanks, is unsubstantiated since Wedekind does not appear to have cut the specimen upon which his section is based. Petter (1960, p. 16, pl. I, figs. 9, 9a) described and figured one specimen which she assigned to this species.

Paired ribbing and strong ventro-lateral tubercles are probably not sufficient grounds for distinguishing at specific level a morphology which is otherwise little different from Gon. (Gon.) subcarinata. However, the argument is not so strong as that for the varieties described above.

Horizon and distribution: The lectotype of Gon. (Gon.) subcarinata came from Schübelhammer, Oberfranken and was reported by Schindewolf (1923a) from the upper zone of the Clymenia Stufe nearby at Kirch-Gattendorf. In the Rheinische Schiefergebirge Wedekind's Gon. (Gon.) praematura came from the lower Vα zone at Hövel, which was confirmed by Lange (1929, his zone Vβ), who together with Schmidt (1924), recorded it and Gon. (Gon.) subcarinata from Hövel (= Melschede) and Dasberg. Wedekind (1914) recorded Gon. (Gon.) tournquisti from the upper Clymenia Stufe, but Lange (1929) recorded this only rarely from his Vβ zone. Petter reported the species from an imprecisely known level in the Clymenia Stufe of the Souara Valley (Algeria).

Subgenus Gonioclymenia (Kalloclymenia) Wedekind 1914

Textfig. 5.10.

Type species: Goniatites subarmatus Münster 1832, by subsequent designation of Schindewolf (1923a, p. 490).

Diagnosis: Similar to Gonioclymenia but lacking a ventral groove, and with an ornament which includes ribs with parabolic tubercles on the ventrad portion of the flank, like Trigonoclymenia Schindewolf.

Available species names include:

subarmata	Münster 1832, p. 28, pl. VI, figs. 2a-c, Schübelhammer, Oberfranken.
crassa	Wedekind 1914, p. 59, pl. 6, figs. 3a-b, Hövel, Sauerland.
?dasbergensis	Wedekind 1914, p. 67, pl. 5, figs. 6a-c, pl. 7, fig. 1, Dasberg, Sauerland.
insignis	Phillips 1841, p. 119, pl. XLIX, fig. 228, Petherwin, England.
lata	Bogoslovskiy 1981, p. 92, pl. XII, fig. 2, pl. XIII, fig. 2, Kiya River, Akt. Oblast'.

pessoides	von Buch 1838, p. 4, pl. I, figs. 1-3, Dzikowiec, Poland.
n. nud. quadrata	Schindewolf 1921, p. 161 (= Gon. (Kall.) biimpressa fide Schindewolf 1937a, p. 44).
uhligi	Frech 1902, p. 41, pl. II(I), fig. 1, Dzikowiec, Poland.

Remarks: Schindewolf's subsequent designation of a type species (1957, p. L40) was unnecessary since he had already (1923a, p. 490) designated subarmata (Münster 1832) as the genotype. Wedekind had failed to nominate a type when he established the genus (1914, p. 65), stating only that it comprised the "Formgruppe Cl. biimpressa". It is not certain, however, that Cl. biimpressa belongs to the subgenus Kalloclymenia, as it is now defined (see below). Various authors (Schindewolf, Lange etc., reviewed in Selwood 1960, p. 158) have discussed the diagnostic validity of the four characters which Wedekind used to distinguish the genus, namely: growth-line shape, ribbing, nature of the whorl cross-section and the absence of a ventral groove. Selwood's conclusion (1960, p. 158) was that Kalloclymenia merited subgeneric status and was distinguished from Gonioclymenia solely by the absence of a ventral groove. Now the major distinguishing factor is considered to be the presence in Kalloclymenia of parabolic tubercles.

In a review of the classification of clymeniid genera Schindewolf (1923b, p. 29) established the genus Otoclymenia with type species Gon. uhligi Frech, distinguished by a sculpture with parabolic ribs and tubercles on the ventro-lateral shoulder. Later, (1937a, p. 55) after noting specimens of Kalloclymenia with a subdued parabolic sculpture he said that Otoclymenia was at most a subgenus, and that there was a graduation in the ornament between Kalloclymenia and Otoclymenia. However, in his species list (1937a, p. 28) he included uhligi as a Kalloclymenia.

In the Treatise (1957, p. L40) Schindewolf retained the subgeneric distinction and characterised Kalloclymenia as being "without distinct parabolic ribs", and Otoclymenia as having "marked parabolic ribs and nodes". However, the original figure of G. subarmatus (Münster 1832, pl. VI, fig. 2a) shows a sculpture with distinct parabolic ribs and nodes up to a diameter of at least 90mm. This figure, however, may be based on several specimens since none has been found resembling it exactly. Since this is the type species of Gon. (Kalloclymenia) the genus must be interpreted as having a Gonioclymenia-type suture, a smooth ungrooved venter and an ornament consisting of ribs with parabolic nodation. Schindewolf's implied statement that degrees of parabolic nodation could be used to differentiate between Kalloclymenia and Otoclymenia is untenable. This is far too subjective a criterion, especially since he did not indicate where the dividing line was to be drawn. Therefore it is better to treat Otoclymenia as a junior subjective synonym of Kalloclymenia, since its only distinguishing character, the presence of a parabolic sculpture is also to be found on Gon. (Kalloclymenia) subarmata, the type species of Gon. (Kalloclymenia).

The species which are recognised as belonging to Gon. (Kalloclymenia) have stratigraphic ranges which are not well known, but are better known than other gonioclymeniids, largely through Schindewolf's (1937a) study of a section through the Wocklumeria Stufe at Oberrödinghausen in the Hönnetal. Gon. (Kalloclymenia) subarmata was reported by Schindewolf (1937a) from the Oberrödinghausen railway-cutting section in Beds 18-16, that is in the middle of the subarmata Zone, and Gon. (Kall.) uhligi (Frech) was reported from Beds 19-8 in the Gon. (Kall.) subarmata Zone and the endogona Subzone. Gonioclymenia (Kall.) crassa (Wedekind) was recorded by Wedekind (1914, p. 59) from the lower Clymenia Stufe at Hövel, and Gon. (Kall.) dasbergensis from the upper Clymenia

Stufe at Dzikowiec and Dasberg. *Gonioclymenia* (*Kall.*) *pessoides* was reported by Schindewolf from Beds 15-19 in the Oberrödinghausen railway-cutting, and is also known from the lower *Wocklumeria* Stufe of Dzikowiec. *Gon.* (*Kall.*) *insignis* is known possibly from the *Clymenia* Stufe of South Petherwin, Cornwall (see Selwood 1960, p. 158, but many of the species from the Landlake Limestone Quarry in Selwood's faunal list occur in the *Wocklumeria* Stufe e.g. *Kosmo. undulata*, *Kosmo. linearis*, *Cyrt. plicata*, *Cyrt. angustisepta*, *Imitoceras* cf. *quadripartitum*). More important is Selwood's fauna (p. 154) from a single horizon where *Cl. hoevelensis*, indicative of the *Clymenia* Stufe, occurs with *Gon.* (*Kall.*) *biimpressa*.

Three of the six known species of *Gon.* (*Kalloclymenia*) are recorded from levels which yield faunas containing genera considered to be indicative of the *Clymenia* Stufe, i.e. *Clymenia* and *Gonioclymenia* (*Gon.*). Whilst these elements could persist into the *Wocklumeria* Stufe it has always been held (e.g. House 1979) that the base of the *Wocklumeria* Stufe can be recognised by the incoming of *Kalloclymenia*, and the simultaneous disappearance of *Clymenia* and *Gonioclymenia*. Clearly this premise would benefit from closer examination of faunas from around the *Clymenia*/*Wocklumeria* Stufe boundary.

Comparisons: The types of all the Western European species of *Gon.* (*Kalloclymenia*) have been examined, most were discussed by Lange (1929). Dimensions are given below for comparison:

	D	U	WW	WH
Gon. (*Kall.*) *subarmata*, lectotype, BSP AS VII 537	100.4 69.0	54.4 37.5	ca20 ca14	24.9 ca18
Gon. (*Kall.*) *uhligi* holotype, MfN c550	68.5	32	19	22

	D	U	WW	WH
Gon. (Kall.) crassa holotype, RE 551. 734.5 A255	52 36	23.6	14.2 10.2	16.2 12.2
Gon. (Kall.) insignis holotype, GSM 7083,a	61 46.5	32.4 24	 ca9	16.7 12.5
Gon. (Kall.) dasbergensis, lectotype, proposed herein as Wedekind 1914, pl.V, figs. 6a-c, pl. fig.1 (the same specimen)	50	21	13	18
Gon. (Kall.) pessoides, lectotype MfN, Pl. 5.5, Figs. 1-3.	31.2	17.9	8.2	7.5

These species are all known from only few examples, from different localities and from uncertain stratigraphic levels. At present any comparison between them can only be based on the type specimens Gonioclymenia (Kall.) uhligi (Pl. 5.5, Figs. 9-11, Textfig. 5.9C) was described by Frech (1902) from only one specimen. It had a quadrate whorl section at a diameter of 65mm, and prominent parabolic tubercles are visible at this point. Gonioclymenia (Kalloclymenia) subarmata (Pl. 5.5, Figs. 8,13,14, Pl. 5.7, Figs. 1,2) has parabolic tubercles up to a diameter of ca 25mm, thereafter there are closely spaced, straight, prorsiradiate ribs which diminish in strength by a diameter of ca 50mm, and seem to be absent on the body chamber. At a diameter of ca 70mm the whorl cross-section is compressed and rectangular. Gonioclymenia (Kalloclymenia) crassa (Pl. 5.5, Figs. 4-7,12, Textfig. 5.9E) lacks a ventral groove (Fig. 7) and cannot be a Gonioclymenia as Wedekind stated (1914). It has prominent parabolic tubercles, lacks ribs and may be synonymous with Gonioclymenia (Kall.) uhligi. Gonioclymenia (Kall.) insignis (Pl. 5.6, Figs. 7-10, Textfig. 5.9D) has parabolic tubercles visible up to a diameter of ca 35mm and strong prorsiradiate ribbing thereafter, persisting to the maximum measured diameter of 61mm.

Gonioclymenia (Kall.) subarmata and insignis have a similar ornament and suture, as do Gon. (Kall.) uhligi and crassa, and thus these pairs may be synonymous. Gonioclymenia (Kall.) dasbergensis appears to be intermediate in character between these two pairs, it has parabolic tubercles up to a diameter of ca 25mm but its ribbing is less prominent than on any other species. Lack of precise stratigraphical control of the collecting horizons of these five nominal species makes any formal consideration of their precise taxonomic relationship unwise. Gonioclymenia (Kall.) pessoides (Pl. 5.5, Figs. 1-3) although known from a small specimen seems a distinct species with slowly increasing whorl height, parabolic tubercles and an apparent lack of ribbing.

Horizon and distribution: The stratigraphic ranges of the various species of Gonioclymenia (Kall.) have been discussed above. The subgenus is known from the upper Clymenia Stufe and the Wocklumeria Stufe of Launceston (England), Montagne Noire (France), Oberfranken, Rheinische Schiefergebirge (W. Germany), Thuringia and Sächische Vögtland (E.Germany), Dzikowiec, Holy Cross Mountains (Poland), the southern Urals (USSR) and the Saoura Valley (Algeria).

Gonioclymenia (Kalloclymenia) subarmata (Münster 1832)

Pl. 5.5, Fig. 13, Pl. 5.6, Figs. 1,2, Pl. 5.7, Figs. 1,2,4,5,

Textfigs. 5.9A,B.

v* 1832 Goniatites subarmatus sp. nov. - Münster, p. 28, pl. VI, figs. 2a-c.

1834b Goniatites subarmatus Münster - Münster, p. 91, pl. VI, figs. 1a-c, (French translation of Münster 1832)

v.	1842	Clymenia subarmata Münster - Münster. p. 123, pl. XII fig. 4.
v?	1841	Goniatites insignis sp. nov. - Phillips, p. 119, pl. XLI, fig. 228.
	1843	Clymenia subarmata Münster - Münster, p. 22, pl. VIa, figs. 2a-c, (copy of Münster 1832).
pv	1863	Clymenia subarmata Münster - Gümbel, p. 157, pl. XXI, figs. 2a-b, non 1a-d.
?.	1873	Clymenia subarmata Münster - Kayser, p. 622, pl. XX, figs. 3a-c.
non	1902	Clymenia subarmata Münster - Frech, p. 41, pl. II(I), fig. 3b, non 3a, (holotype of Subgen. Nov. B brevispina Lange 1929).
(?.)	1914	Kalloclymenia subarmata Münster - Wedekind, p. 66.
(?.)	1923a	Kalloclymenia subarmata Münster - Schindewolf, p. 491.
?.	1960	Kalloclymenia subarmata (Münster) - Petter, p. 17, pl. I, figs. 8-b.
v?	1960	Gonioclymenia (Kalloclymenia) biimpressa (von Buch) - Selwood, p. 159, pl. 26, fig. 2, (refiguring of the holotype of Gon. insignis Phillips).
non	1962	Kalloclymenia subarmata (Münster) - Bogoslovskiy, pl. XXI, fig. 3, (= Costaclymenia (Cost.) binodosa).
?	1981	Kalloclymenia subarmata (Münster) - Bogoslovskiy, p. 90, pl. XII, figs. 2a,b, textfig. 38.

Type material: BSP AS VII 537, Münster Collection, Schübelhammer, Oberfranken, is proposed as the lectotype.
Diagnosis: Gonioclymenia (Kalloclymenia) with straight prorsiradiate ribs present to a diameter of at least 50mm, and parabolic tubercles up to a diameter of 30mm.

Description: Only the lectotype, BSP AS VII 537, is well enough preserved to be described. Other specimens from Münster collections (SM H10394, BM 81834, BSP AS VII 593) have little ornament remaining and therefore cannot be assigned, with certainty, to this subgenus.

Shell evolute, with a quadrate compressed whorl section and slightly arched venter. Inner whorls are damaged but parabolic tubercles are visible at a diameter of ca 15mm and persist to a diameter of ca 30mm. Thereafter there are closely spaced straight or S-shaped prorsiradiate ribs, numbering 16 in the half whorl prior to a diameter of ca 50mm. The last whorl of the lectotype is weathered but appears to have faint, broad ribs. The suture (Textfig. 5.9A) is of the <u>Gonioclymenia</u>-type, with the same number of elements but the largest, midflank, lateral lobe has a characteristic broad, spearhead-shape.

Dimensions:

	max D	D	U	WW	WH	A
Lectotype, BSP	115	100.4	54.4	ca20	24.5	
AS VII 537		69	37.5	ca14.5	ca18	
SM H10394		103.8	53	22.5	29.5	28.2
		ca 76	38.8	17.7	ca21	ca20.5
		55.5	ca27.5	12.7	16	15.0
		35.5	18.9	9.1	11.8	11.2
		27.9		ca5.4	9	
Münster 1832		180	96	32	24.5	
pl.VI, figs.2a-b		140	35		16	

Remarks: Munster's (1832) figure of this species is of an individual much larger than the lectotype. It has slightly different ornament. Parabolic tubercles are shown as present up to a diameter of ca 90mm. However, no specimen exactly resembling this figure can be traced and it may be composite, based on several specimens. The specimen regarded by Gümbel (1863) as Münster's original has been designated the lectotype, since it partly resembles Münster's 1832 figure, and is considered to be a syntype.

In 1842 Münster figured a second specimen, (pl. XII, fig. 4) from Gattendorf. He (p. 123) added little to his previous description, and the figured specimen (BSP AS VII 593, Pl. 5.6, Figs. 1,2) is extremely poorly preserved. The only reason Münster seems to have had for referring again to this species was to comment on the similarity of ornament between it and the new species Clymenia spinosa. Both have parabolic ventro-lateral tubercles.

The relationship between this species and others included in Gonioclymenia (Kalloclymenia) has already been discussed (see Gonioclymenia (Kalloclymenia) above). The holotype and only known specimen (GSM 7083,A) of Gon. (Kall.) insignis (Phillips) has parabolic tubercles visible up to a diameter of 35mm and therefore may be synonymous with Gon. (Kall.) subarmata. The type specimens of Gon. (Kall.) uhligi (MfN c550) and Gon. (Kall.) crassa (RE 734.551.5 A255) still have parabolic tubercles at diameters of 65 and 55mm respectively (Pl. 5.5, Figs. 4,10) and thus are closer in appearance to Münster's figure of Gon. (Kall.) subarmata than the lectotype. Gon. (Kall.) crassa was referred by Wedekind to the genus Gonioclymenia but since it lacks a ventral groove this cannot be correct. These two species have sutures which show some differences from Gon. (Kall.) subarmata and insignis. In Gon. (Kall.) crassa and uhligi the midflank lateral lobe and the ventral lobe are deeper and narrower (Textfigs. 5.9C,E) which may in itself be sufficient for a taxonomic distinction to be drawn.

The holotype (MfN c600) of Subgen. Nov. B biimpressa (von Buch) is figured in Pl. 5.8, Figs. 7,8, (Subgen. Nov. B is discussed below). It lacks parabolic tubercles, and therefore cannot be assigned to Gon. (Kalloclymenia). This lack may be due principally to the poor preservational state of the holotype, which came from Dzikowiec. Many authors have commented on the relationship between it and Gon. (Kall.) subarmata. Lange (1929), who refigured the holotype (pl. 2, fig. 10) considered that the differences between them lay in the ribbing. He said that Gon. (Kall.) subarmata still had ribbing at a stage where it had disappeared in Subgen. Nov. B biimpressa. However, since at its maximum diameter of 42mm the holotype of Subgen. Nov. B biimpressa still has ribbing of similar strength to that of the lectotype of Gon. (Kall.) subarmata at the same diameter, this statement is impossible to disprove, and so is useless in helping to diagnose the species. In view of the poor state of preservation of the holotype Subgen. Nov. B biimpressa is a species best regarded as a nomen dubium.

Horizon and distribution: The lectotype came from Schübelhammer, Oberfranken and Schindewolf reported the species from Dzikowiec (1937a), Beds 18-16 (Kalloclymenia subarmata Zone) at Oberröding-hausen, Sauerland (1937a) and Bed 20 at Kirch-Gattendorf (1923a). Gonioclymenia (Kalloclymenia) insignis is known from the Petherwin Beds Cornwall. The two precisely known horizons are both in the subarmata Zone.

Gonioclymenia (Subgen. Nov. B)

Proposed name: Langeclymenia, in recognition of W. Lange.
Type species: Gonioclymenia (Kalloclymenia) wocklumensis Lange 1929, p. 79, pl. 2, figs. 18,a, designation proposed here.
Diagnosis: Gonioclymenia with flatly arched venter at all stages, and with ornament consisting of subdued ribs on the flanks at most, lacking spines near the umbilicus, and parabolic tubercles at or near the venter.

Comparisons: This genus is similar to Gon. (Kalloclymenia) but lacks the parabolic tubercular ornament of that genus.

Available species names include:

*wocklumensis	Lange 1929, p. 79, pl. 2, figs. 18,a, Burg, Wocklum, Sauerland.
?frechi	Lange 1929, p. 81, Dzikowiec, Poland.
glabra	Bogoslovskiy 1981, p. 96, pl. XV, fig. 5, textfig. 42, Loz'ra R., Tumenskaya Oblast', n. Urals.

<u>kozhimensis</u>	Bogoslovskiy and Kuzina 1980, p. 69, pl. IX, fig. 1, textfig. 1, Kozhima R., Komi ASSR, n. Urals.
<u>linguilobata</u>	Bogoslovskiy 1981, p. 91, pl. XIII, fig. 1, text-fig. 39a, Kiya R., Akt. Oblast', s. Urals.

and other species, only questionably included are:

<u>angusta</u>	Münster, 1839 (see Gonioclymeniidae above).
<u>biimpressa</u>	von Buch, 1838, p. 5, pl. II, figs. 1-3, Dzikowiec.
<u>clymeniaeformis</u>	Münster 1842 (see Gonioclymeniidae above).
?<u>pachydiscus</u>	Bogoslovskiy 1981, p. 94, pl. XIII, fig. 3, text-figs. 40a,b, Kiya R., Akt. Oblast', s. Urals.
<u>vincta</u>	Sowerby 1840, p. 703, pl. XLIV, fig. 18.

Schindewolf (1937a, p. 28) implied that there were two other related species, <u>Kall</u>. <u>wocklumensis</u> mut. nov. and <u>Kall</u>. sp. nov. aff. <u>wocklumensis</u>. These, however, were not described.

Remarks: <u>Goniatites</u> <u>clymeniaeformis</u> and <u>G</u>. <u>angustus</u> may belong in this genus. The former was figured by Münster (1839, pl. XVII, figs. 4a-c) and described (p. 24) as being evolute, smooth shelled with a quadrate compressed whorl section, and suture consisting of two lateral lobes (similar in shape to those on <u>Sellaclymenia</u>) and a ventral lobe. This description was modified by Gümbel (1863, p. 153, pl. XX, figs. 2a,b), who said that the original specimen was a weathered mould. His figures showed the flanks converging to a rounded smooth venter and also a shallow ventro-lateral lobe, as well as a ventral lobe. Münster's description of the suture may be inaccurate; it resembles that of <u>Mesoclymenia</u> Bogoslovskiy although Gümbel's illustration (1863, pl. XXI, fig. 2b) shows an adventive lobe. There is a great resemblance in shell form between <u>Gon</u>. <u>clymeniaeformis</u> and Subgen. Nov. <u>A</u> <u>frechi</u>, but since no more of Münster's specimens can be traced, no more than this can be said.

<u>Goniatites</u> <u>angustus</u> may also belong in this genus. It was

considered by Schindewolf (1923a) to be a Sphenoclymenia, but Münster (1839) had clearly stated that this species had a suture which was similar to Gon. (Kall.) subarmata. A specimen in the Münster Collection at Cambridge, SM H10314, is designated as the lectotype. It is, however, poorly preserved (Pl. 5.6, Fig. 4) and the species should be considered as a nomen dubium since it cannot be described, nor distinguished from Gon. (Kall.) subarmata.

The status of Subgen. Nov. B biimpressa is somewhat similar. It has already been discussed (see above, Gonioclymenia (Kalloclymenia) Remarks) and its holotype is poorly preserved. Subgen. Nov. B frechi (Lange 1929) also has as its type a specimen which is poorly preserved (Pl. 5.8, Figs. 2-4, Textfig. 5.9F). It is discussed below.

The holotype of Goniatites vinctus Sowerby (p. 703, pl. XLIV, fig. 18), recorded from Barnstaple, is recognised as SM H4015 (Pl. 5.6, Fig. 3). It lacks shell and therefore cannot be excluded with certainty from Kalloclymenia. The ribs are not so strong as illustrated by Sowerby. The flanks are converging and this feature alone may permit the recognition of Subgen. Nov. B vincta as a distinct species, but more material must be collected to demonstrate this.

Various new species of Gonioclymenia and Kalloclymenia recently introduced by Bogoslovskiy (1981) are very poorly documented. Most are based on few poorly preserved specimens, indeed only one (Gon. (Gon.) levis) is represented by more than one example. Hence little useful can be said of the four species listed above. Subgen. Nov. B kozhimensis and glabra lack ornament and have the same shell form and coiling as Gon. (Subgen. Nov. B) wocklumensis, and thus may be synonymous.

Horizon and distribution: Examples are known from the paradoxa and evoluta Zones of the Rheinische Schiefergebirge, Thuringia, England, Poland, Urals and North Africa.

Gonioclymenia (Subgen. Nov. B) wocklumensis (Lange 1929)

Pl. 5.8, Figs. 1,5,6, Textfig. 5.9G

v* 1929 Gonioclymenia (Kalloclymenia) wocklumensis sp. nov. - Lange, p. 79, pl. 2, figs. 18,a, textfigs. 14,15.
1959 Kalloclymenia wocklumense - Pfeiffer, p. 263.
? 1960 Kalloclymenia wocklumensis Lange - Kullmann, p. 531, pl. 8, fig. 1, textfig. 17a,b.
? 1960 Kalloclymenia wocklumensis Lange - Petter, p. 17, pl. I, figs. 4,5, textfig. 2C.

Type material: The holotype (MfN), from Burg near Wocklum, Sauerland, is figured here (see above). There were five paratypes, none of which have been traced.
Diagnosis: Species of Gon. (Subgen. Nov. B) with converging flanks, flattened venter and faint plicate ribs, U/D = 0.38.

Description: A description is based on the slightly distorted holotype. Subevolute, inner whorls appear to be half embraced by succeeding whorls. Whorl section is a compressed trapezoid, flanks are converging and flat. Inner whorls are not preserved, or have been damaged by preparation. At a diameter of 50mm and greater, S-shaped growth-lines and faint plicate ribs are visible. The suture is illustrated in Textfig. 5.5.

Dimensions:

	D	U	WW	WH
Holotype, MfN	45	17	10	16.8
Pl. 5.8, Figs. 1,2.			6.5	11

Remarks: This species is a near homeomorph of Sell. plana Münster, but is distinguished by the presence of ribbing, and a ventral lobe, and has thicker whorls. The fragment of a whorl figured by Kullmann (1960) can only be questionably included here, since it is poorly preserved, and the same reservation must be applied to the two specimens, one a juvenile, and the other an internal mould, figured by Petter (1960). The species was reported by Selwood (1960) from Launceston, though not figured.

Horizon and distribution: The type locality of this species is recorded as Burg, Wocklum, Sauerland and it is also known from the Beds 4-1, and the Hangenberg Schiefer at Oberrödinghausen, Saalfeld, Launceston and possibly from Algeria and the Cantabrian Mountains.

<u>Gon</u>. (Subgen. Nov. <u>B</u>) aff. <u>wocklumensis</u> Lange 1929

Pl. 5.8, Fig. 10, Textfigs. 5.9H,I.

Material: One specimen, SM H10373 (Pl. 5.8, Fig. 10, Textfigs. 5.9H,I) in the Münster Collection at Cambridge, from Schübelhammer, Oberfranken, has been seen.

Description: The inner whorls have been dissolved by pressure solution but the outer whorls are preserved and shown in Textfig. 5.9I. The ventral area has a shallow depression running along it at diameters of 50 and 72mm. The flanks are rounded and converging towards the venter. Broad plicate, slightly sinuous ribs are visible up to a diameter of ca 90mm, thereafter the flanks are smooth. The suture is illustrated in Textfig. 5.9H. Differences between the suture of this specimen and the holotype are likely to be caused by the polished nature of the holotype, and their differences in size.

Interestingly the siphuncle is preserved in the last whorl seen, at a diameter of 140mm. It is visible as a thin black ring within the funnel of the dorsal lobe, and its depressed, sub-circular shape can be seen in the cross-section (Textfig. 5.9I).

Dimensions:

	D	U	WW	WH
SM H10373	140	50.5	31.4	51.6
	58	22.5	12.5	22
	38	-	8	12

Horizon: There is no evidence of the age of this specimen but it is presumed to come from the lower Wocklumeria Stufe.

Gonioclymenia (Subgen. Nov. B) frechi (Lange 1929)

Pl. 5.8, Figs. 2-4, Textfigs. 5.9F

pvp 1902 Gonioclymenia pessoides von Buch - Frech, p.38, pl. II(I), figs. 14a (lectotype), b, textfig. 6a (P. 40).

1914 Gonioclymenia pessoides von Buch - Wedekind, p. 66, pl. 5, figs. 5, (refiguring of Frech 1902, pl. II(I), fig. 14b).

v* 1929 Gonioclymenia (Kalloclymenia) frechi nom. nov. - Lange, p. 81.

Type material: A lectotype, MfN, from Dzikowiec, Poland, is proposed here.

Lange (1929, p. 81) nominated as the holotype of this species two of Frech's figures (1902, pl. II(I), figs. 14a,b) and this designation is therefore invalid. The specimen figured in the former of these is selected as the lectotype. The specimen represented by the latter was figured by Wedekind (1914, pl. V, fig. 5) but was housed at Wrocław, and is now presumed to have been destroyed.

Diagnosis: Species of Gon. (Subgen. Nov. B) lacking ornament apart from small ventro-lateral tubercles visible up to a diameter of ca 25mm.

Description: The description is based on the lectotype. Evolute with compressed quadrate whorl section. Flanks slightly rounded and converging to flatly rounded venter. Small ventro-lateral tubercles are visible between diameters of ca 10 and 25mm, otherwise there is no ornament and the flanks are smooth. The ribbing indicated near the aperture on Frech's figure (1902, pl. II(I), fig. 14a) is not so strong as illustrated.

The suture is illustrated in Textfig. 5.9F, although at the point on the shell where it is visible there has been much filing and polishing. Therefore the elements are bound to be somewhat smoothed.

Dimensions:

	D	U	WW	WH
Lectotype, MfN	71.6	39.3	14.4	18.4
Pl. 5.8,Figs.2-4.	59.2	30	11.2	15.1

Horizon and distribution: The lectotype comes from the Wocklumeria Stufe of Dzikowiec (Poland). Schindewolf (1937a) reported the species from Oberrödinghausen, Sauerland, in Bed 9, which is in the endogona Subzone of the Wocklumeria Stufe.

Gonioclymenia (Subgen. Nov. A)

Textfig. 5.11

Proposed name: Silesiclymenia (after Silesia).
Type species: Gonioclymenia (Kalloclymenia) brevispina, Lange 1929, designation proposed here.
Diagnosis: Gonioclymenia with arched, rounded venter and spinose ornament on ventro-lateral and umbilico-lateral shoulders.

Description: The genus has a Gonioclymenia (Kalloclymenia) - type suture and the only species has a very compressed whorl section.

Available species names include:

*brevispina Lange 1929, p. 83, Dzikowiec, Poland.
interrupta Schmidt 1924, non Münster 1842, p. 139, pl. 7, figs. 9,a, Wildungen, Kellerwald.

Remarks: Only the type species is well known. Gonioclymenia interrupta sensu Schmidt 1924, p. 17, fig. 9,a, non Münster 1842, may represent another species.

Bogoslovskiy (1981, pl. IX, figs. 1a,b) figured an example of "Gonioclymenia interrupta (Münster)". This had a number of thin spines projecting from the ventro-lateral shoulder and partially enveloped by succeeding whorls, and thus resembles the ornament on Schmidt's (1924) specimen, of the same name, but this lacks a ventral groove, hence its inclusion in this subgenus. The Russian specimen has a clear ventral groove and thus may be a Gonioclymenia. It does not, however, resemble Münster's figure, and represents an incorrect use of the specific name.

Horizon and distribution: Species are known from the subarmata and paradoxa Zones of England, Rheinische Schiefergebirge, Oberfranken (W. Germany), Urals (USSR) and North Africa.

Gonioclymenia (Subgen. Nov. A) brevispina Lange 1929

Pl. 5.9, Figs. 6-10

vp 1902 Gonioclymenia subarmata Münster - Frech, pl. II(I), fig. 3a only.
v* 1929 Gonioclymenia brevispina sp. nov. - Lange, p. 83.

Type material: The holotype, from Dzikowiec (Dolny Śląsk = Silesia, Poland) has been recognised in the Museum für Naturkunde, Berlin.
Diagnosis: Species of Gonioclymenia (Gen. Nov. A) with a strongly compressed whorl section and prominent rectiradiate ribs terminated by spinose tubercles on the ventro-lateral shoulders of early whorls. These ribs degenerate, becoming radial and low joining tubercles on the ventro-lateral and umbilico-lateral shoulders.

Description: Two specimens have been seen, the holotype (Pl. 5.9, Figs. 9,10) and a specimen (Pl. 5.9, Figs. 6-8) from Bed 11 in Schindewolf's (1937a) Oberrödinghausen section. The holotype is a small broken specimen, One half is preserved partly as an external mould and partly just as shell, and the other half has solid form, with the shell being polished away to reveal a Kallo-clymenia-type suture. The inner whorls are not well preserved. At a diameter of ca 10mm widely spaced, radial ribs are visible terminated on the ventro-lateral shoulder by spinose tubercles. By the next whorl, at a diameter of ca 14mm, tubercles are present on both margins of the flanks. On the body chamber at a diameter of ca 22mm the ribs have become more closely spaced, and are just low folds joining two tubercles. The ventro-lateral tubercle is at this stage far less spinose.

Schindewolf's specimen shows several features in common with the holotype, especially the spinose ventro-lateral tubercles of middle whorls and the closely spaced, diminished tuberculate ribs of the body chamber. Therefore, it is considered to be conspecific. The early whorls, up to a diameter of ca 4mm are smooth. There-after, straight rectiradiate ribs develop which extend at the ventro-lateral shoulder to form tubercles, and then spines, which are enveloped by the succeeding whorl, by a diameter of 7mm. The ribs then become progressively less rectiradiate and diminish in strength, reducing to two tubercles only at a diameter of 15mm. The next three quarters of a whorl is missing. The body chamber has a very compressed, quadrate whorl section with parallel flanks and rounded venter. At a diameter of 30mm the internal mould shows shallow ribs joining two tubercles of equal strength. On the last part of the body chamber preserved, at a diameter of ca 35mm, the umbilico-lateral tubercles become more closely spaced and the ribs and ventro-lateral tubercles disappear.

Dimensions:

	D	U	WW	WH
Holotype, MfN	21			
MfN, Pl.5.9,Figs.6-8	34.4	ca14.2	4.1	11

Remarks: Lange avoided any confusion over the status of this species with a statement of designation exhibiting rare precision: "Frech's Gonioclymenia subarmata 1902, Taf. 2, 3a stellt dagegen ein andere neue Art dar = Gonioclymenia brevispina nom. nov." Frech's figure was a composite (see Frech 1902, pl. II(I) explanation) the inner five whorls of which were based on a specimen from Wrocław, and the outer whorl was based on a specimen in Berlin. Lange designated this latter specimen as the holotype, and it is figured here. Lange considered the specimen on which the inner whorls of Frech's figure were based to be Gon. (Subgen. Nov. B) biimpressa.

Horizon and distribution: The species is known from the Wocklumeria Stufe of the type locality, Dzikowiec, and from the Sauerland, where Schindewolf (1937a) reported it from Beds 13-11 at the top of the "Kalloclymenia subarmata and brevispina Zone" (lower Wocklumeria Stufe). He also reported it questionably from Bed 22. Evidence for this latter occurrence came from the recognition of this species in two levels at Dzikowiec. The upper one he correlated with Beds 11 and 10 of his Oberrödinghausen section, and the lower one with "Bed 22?". The reasoning for this (1937a, p. 21) was that brevispina was a species occurring, albeit questionably, in the Wocklumer Schichten, "auf Grund der Kalloclymenia brevispina gehort sie aber zweifellos noch den Wocklumer Schichten an".

This opinion is unfounded, and other taxa reported as occurring with Gen. nov. A brevispina, i.e. Cymaclymenia striata, Kosmoclymenia bisulcata and Kosmoclymenia cf. undulata, were all names misinterpreted by Schindewolf, and their horizon can be stated only as Clymenia or Wocklumeria Stufen.

Subfamily Sphenoclymeniinae nov.

Type genus: Sphenoclymenia Schindewolf 1920.
Diagnosis: Gonioclymeniidae with additional umbilical or adventive lobes.

Two genera are recognised:

Schizoclymenia Schindewolf 1920
Sphenoclymenia Schindewolf 1920

Remarks: Schizoclymenia Schindewolf 1920 was regarded by Schindewolf (1957) as a synonym of Gonioclymenia, and he stated that it was based on a misinterpretation of the internal suture of a specimen figured by Drevermann (1901, pl. XIII, fig. 10)as Clymenia sp. This single specimen formed the basis for a new species, Schiz. drevermanni Schindewolf 1920, but I have been unable to locate the specimen amongst the collections at Marburg, where most of the material figured by Drevermann (1901) is held.

Horizon and distribution: Known from the Clymenia and Wocklumeria Stufen of Germany, North Africa and the Urals.

Genus Sphenoclymenia Schindewolf 1920

Type species: Goniatites maximus Münster 1832, by original designation of Schindewolf 1920, p. 128.
Diagnosis: Member of the Gonioclymeniidae with ventral, four lateral, umbilical and dorsal lobes.

Description: Evolute, with compressed fastigate or quadrate whorl section. Ornament is lacking or consists of plicate ribs, or ventro-lateral spines. The suture is illustrated in Textfig. 4.11, most of the elements are pointed. According to Schindewolf (1924, p. 98) the second umbilical lobe may be either inside or outside the umbilical seam.

Available species names include:

*maxima	Münster 1832, p. 29, pl. VI, fig. 3, Schübelhammer, Oberfranken.
apertus	Richter 1848, p. 36, pl. IV, figs. 125-6, Saalfeld, Thuringia.
intermedia	Münster 1839, p. 29, pl. XVIII, fig. 7, Schübelhammer, Oberfranken.
plana	Bogoslovskiy 1981, p. 103, pl. XVI, figs. 1,2, textfig. 46, Kiya River, Aktyubinskaya Oblast'.

Schindewolf (1937a) p. 28) also recognised an unnamed species from Bed 17 at Oberrödinghausen.

Remarks: Schizoclymenia Schindewolf 1920, with type species drevermanni was diagnosed by having one lobe less than Sphenoclymenia (cf. Textfigs. 4.11A,C). Only one specimen has been illustrated (Drevermann 1901, pl. XIII, fig. 10), and it is questionable whether a generic distinction on the basis of the absence of a ventro-lateral lobe is useful, especially when Sphen. intermedia (Textfig. 4.11,B) has only a weak ventro-lateral lobe.

Horizon and distribution: The genus is known from the Clymenia and Wocklumeria Stufen of Oberfranken and Sauerland (W. Germany) and Thuringia (E. Germany), the Souara Valley (Algeria), and Aktyubinskaya Oblast', southern Urals (USSR).

Sphenoclymenia maxima (Münster 1832)

Textfig. 4.11A

* 1832 Goniatites maximus sp. nov. - Münster, p. 29, pl. VI, fig. 3.

1834b Goniatites maximus Münster - Münster, p. 92, pl. VI, fig. 2, (French translation of Münster 1832).

1839 Goniatites maximus Münster - Münster, p. 30, pl. XVIII, fig. 8.

1843 Goniatites maximus Münster - Münster, p. 22, pl. VIa, fig. 3 (copy of Münster 1832) p. 54, pl. XVIII, fig. 8, (copy of Münster 1839).

p 1863 Clymenia intermedia Münster - Gümbel, p. 157, pl. XXI, figs. 4a-b.

1902 Gonioclymenia maxima Münster - Frech, p. 42, textfig. 7.

1920 Sphenoclymenia maxima Münster - Schindewolf, p. 128, textfig. 2d.

1923a Sphenoclymenia maxima Münster - Schindewolf, p. 481, textfig. 21d.

Type material: No type material has been identified. Interpretation of the species is not in question, so no neotype has been proposed.

Diagnosis: Sphenoclymenia with a fastigate venter and a relatively deep, pointed ventro-lateral lobe (Textfig. 4.11A).

Description: The description is based solely on the figures of Münster (1832, 1839) and Gümbel (1863). The whorl section is subtriangular between whorl heights of 80 and 140mm. The impressed area is small and shallow and the flanks are smooth. The suture consists of 12 mostly angular saddles and lobes (Textfig. 4.11A, based on Schindewolf's 1920 figure). The ventro-lateral lobe is pointed and half as deep as the outer lateral lobe. Frech and Schindewolf(1920) both showed the umbilical lobe as being inside the seam.

Remarks: Münster based his original description on a fragment of a specimen, of which he only figured a cross-section (1832, pl. VI, fig. 3). He stated that the suture was similar to Gon. (Kall.) subarmata, but that the ventro- lateral lobe was on the flank. Later he described and figured a fragment on which the suture over the flanks was seen to contain not three but four lobes (1839, pl. XVIII, fig. 8). Gümbel figured the same specimen with greater accuracy, which was improved upon further by Frech (1902, textfig. 7). Although Schindewolf made this species the type of his new genus Sphenoclymenia he did not at this time, nor later, redescribe it. This suggests that he did not examine Münster's figured material, and it cannot be found today.

Horizon and distribution: The type locality is Schübelhammer, Oberfranken, and the species was also reported by Schindewolf (1937a) from Bed 12 in the Kall. subarmata Zone at Oberrödinghausen, Sauerland.

Sphenoclymenia intermedia (Münster 1832)

Pl. 5.9, Figs. 1-5, Textfigs. 5.7F,G

(?) 1831 Nautilus intermedius sp. nov. - Münster, p. 181.
*v 1839 Goniatites intermedius Münster - Münster, p. 29, pl. XVIII, fig. 7.
v 1843 Goniatites intermedius Münster - Münster, p. 53, pl. XVIII, fig. 7, (copy of Münster 1839).

pv 1863 Clymenia intermedia Münster - Gümbel, p. 73, pl. XXI, figs. 3a-e.
1902 Clymenia plana var. intermedia Münster - Frech, p. 40.
1924 Sphenoclymenia intermedia Münster - Schindewolf, p. 101.
1960 Sphenoclymenia intermedia Münster - Petter, p. 18, pl. 2, figs. 15,a,16, textfig. 2A.

Type material: BSP AS VII 586, from Schübelhammer, Oberfranken, is proposed as the lectotype and figured here, Pl. 5.9, Figs. 3-5.
Diagnosis: Sphenoclymenia with quadrate whorl section and shallow ventro-lateral lobe.

Description: The lectotype is a large, weathered specimen on which no inner whorls are preserved. It is evolute with a compressed whorl section and flanks converging slightly to a broad rounded venter. The ornament consists of broad, low slightly sinuous radial ribs. The suture is illustrated in Textfig. 5.9F.

Another specimen, SM H10397, has also been seen. It is a fragment of a whorl which has been polished to show the suture (Pl. 5.9, Figs. 1-2, Textfig. 5.9F). This specimen shows the whorl section well. The flanks converge more strongly than on the lectotype and they appear to be unornamented, but they are weathered or polished. The course of the suture is visible over the umbilical wall where there is a shallow lobe, centred outside the presumed position of the umbilical seam. There is no such lobe visible on the lectotype, but this may be caused by the failure to prepare the suture well enough to reveal such a lobe.

Dimensions:

	D	U	WW	WH	A
Lectotype, BSP AS	126	57.1	21.5	39.5	ca35
VII 586	88	ca38	vca17	31	
			13.1	23.8	22.5
SM H10397			22.3	44.7	41.6

Remarks: Münster's (1839) figure is a very diagrammatic sketch of a suture, but it shows the characteristic shallow ventro-lateral lobe drawn more accurately on Gümbel's (1863) figure. Both Münster and Gümbel figure specimens of similar size, and therefore, the specimen figured by Gümbel is considered as the lectotype. This seems to have lost its inner whorls since Gümbel's figure was drawn.

Comparisons: This species is differentiated from Sph. maxima by the whorl cross-sectional shape, and the depth of the ventro-lateral lobe. Schindewolf (1924) stated that in Sph. maxima the umbilical lobe was centred inside the seam, and outside the seam in Sph. intermedia. It has already been stated that no umbilical lobe is present on the lectotype of Sph. intermedia, which may indicate that the umbilical lobe, if present, is internal, or that no such lobe is developed, or is hidden beneath matrix. Petter (1960, textfig. 2A) shows a shallow umbilical lobe centred on the seam.

Goniatites apertus was recognised by Richter (1848) possibly to be a synonym of Sph. intermedia. Richter's figures (pl. IV, figs. 125,6) show a Sph. intermedia-type suture and a whorl section which converges to a flattened venter, and so can be regarded as similar to Sph. intermedia. The specimen is , however, a juvenile and so assignation to this species cannot be certain.

Sphenoclymenia plana Bogoslovskiy has a much more compressed whorl section, and a spinose ornament on the ventro-lateral shoulder.

Horizon and distribution: The species is known from Sauerland, Oberfranken, Bohlen, Thuringia, and Ouarourout and the Souara Valley. Both Schindewolf (1924) and Petter (1960) considered it to be from the Clymenia Stufe.

Suborder Clymeniina Wedekind 1914

Diagnosis: Clymeniida in which the ventral lobe is replaced by a saddle early in ontogeny. Sutural pattern basically comprises lateral and dorsal lobes, elaborated by formation of secondary ventral lobes and adventive, lateral and umbilical lobes.

Remarks: Sutural variation within this suborder is far less marked than in the Gonioclymeniina, and authors have recognised only one superfamily, Clymeniaceae. Similarly there is far less variety of shell form than in the Gonioclymeniina, but there is greater variation in growth-line shape, which is used to distinguish families and genera (see Chapter 4).

Horizon and distribution: Representatives range from the ?*sandbergeri* or *delphinus* Zones to the *evoluta* Zone. *Cymaclymenia evoluta* from the Hangenberg Schiefer of the Sauerland is the youngest known clymeniid. House (1970) has argued that the Clymeniida evolved from the Tornoceratidae, via *Tornia* and *Platyclymenia*. Clymeniina are known from all continents, except Antartica and South America.

Superfamily Clymeniaceae Edwards 1849

Diagnosis: As for the suborder.

Included families: Cyrtoclymeniidae Hyatt 1884, Platyclymeniidae Wedekind 1914, Rectoclymeniidae Schindewolf 1923a, Carinoclymeniidae Bogoslovskiy 1975, Clymeniidae Edwards 1849 and Cymaclymeniidae Hyatt 1884.

Remarks: Subdivision into groups at familial level is rather arbitrary, which reflects the lack of knowledge of the relationship between them.

Family Platyclymeniidae Wedekind 1914

Type genus: Platyclymenia Hyatt 1884.
Diagnosis: Clymeniaceae with evolute to subevolute shell form. Growth-lines are concave, or concavo-convex. The suture is simple, with a broad lateral lobe and a dorsal lobe, and sometimes a ventral lobe. In Subfamily Nov. α this pattern is modified by the addition of adventive or umbilical lobes.

Remarks: Two subfamilies are recognised, Platyclymeniinae and Subfamily Nov. α, distinguished by their sutures.

Horizon and distribution: Examples are known from North America, Europe, N. Africa, Urals, Iran, and Australia, from the Platyclymenia and Clymenia Stufen.

Subfamily Platyclymeniinae Wedekind 1914

Type genus: Platyclymenia Hyatt 1884.
Diagnosis: Coiling evolute and discoidal with concave growth-lines over the flanks. The simple suture consists of dorsal and lateral lobes and a ventral saddle, sometimes there is an umbilical lobe, and sometimes a ventral lobe.

Description: Evolute, U/D varies from 0.3-0.6 and WW/WH varies from 0.5-2.25. Whorl cross-section varies between depressed reniform, circular and quadrate compressed. Growth-lines are concave or straight, radial or prorsiradiate and there is a ventral sinus. Concave ribs on the flanks are common. Parabolic ribs and ventral spines are also known.

Included genera:

Platyclymenia	Hyatt 1884
(Plat.) Pleuroclymenia	Schindewolf 1934
(Plat.) Trigonoclymenia	Schindewolf 1934
(Plat.) Spinoclymenia	Bogoslovskiy 1962
Stenoclymenia	Lange 1929
?Trochoclymenia	Schindewolf 1923a

Remarks: Following Schindewolf (1934) Platyclymenia has been divided using the characters of whorl sectional shape and growth-line course, into four subgenera: Platyclymenia, Pleuroclymenia, Trigonoclymenia and Spinoclymenia. Spinoclymenia and Trigonoclymenia, diagnosed by their distinctive ornament, are clear.

Schindewolf (1934) illustrated the simple growth-lines of Platyclymenia (Plat.), but the specimen he illustrated (1923a, pl. XVII, fig. 8) as annulata, the type-species, has growth-lines which are transitional between Platyclymenia ss. and Trigonoclymenia (see Textfig. 5.12J). Pleuroclymenia, illustrated (Schindewolf 1934) by depressed species from Raymond's (1909) Three Forks Shale fauna, from Montana USA, has as its type species crassissima Schindewolf 1955. This has growth-lines which are concave (Textfig. 5.12G), and a whorl section which although depressed, approaches the field occupied by typical Platyclymenia. It is certainly more similar to species of Platyclymenia than to the American species of Pleuroclymenia (vide Textfigs. 5.13, 5.12G,J and 4.12G,H), which are very depressed (WW/WH >2), and have convex growth-lines.

Trochoclymenia, which has a shallow umbilical lobe and a ventral saddle, is only questionably included here (see Chapter 4).

Its sutural ontogeny is unknown but if Petter (1960) is correct in dating Troch. ornata as from the Platyclymenia Stufe of Algeria (Marhouma) then it is more likely to be a near homeomorph of Costaclymenia (which has a ventral lobe) than a relation of it, since this is not known until the Clymenia Stufe (however, Bogoslovskiy (1981) has reported Costaclymenia from the Platyclymenia Stufe of Kazakhstan).

Horizon and distribution: Examples are mostly confined to the delphinus and annulata Zones, and are known from Oberfranken, Rheinische Schiefergebirge, Thuringia (Germany), Holy Cross Mountains (Poland), England, Montagne Noire (France), Carnic Alps (Austria-Italy), Urals, Kazakhstan (USSR), north eastern Iran, Pakistan, Australia, North West Territories (Canada), and Montana (USA). Bogoslovskiy (1962) reported Spinoclymenia from the Clymenia Stufe of the southern Urals.

Genus Platyclymenia Hyatt 1884

Type species: Goniatites annulatus Münster 1832, by subsequent designation of Frech 1902, p. 32, footnote 2.
Diagnosis: Member of the Platyclymeniinae with growth-lines which are concave, radial or prorsiradiate, with a sinus over the venter. The suture is simple consisting of a ventral lobe, a broad lateral lobe and a dorsal saddle.

Description: Shell evolute to ?subevolute, whorl cross-section circular to subcircular or quadrate, with converging flattened flanks. Growth-lines are concave, either radial or prorsiradiate, with a sinus over the venter. The suture is simple with a dorsal lobe, a lateral lobe and a ventral saddle. Perna (1914, p. 60) suggested that the genus could be distinguished from the morphologically similar Cyrtoclymenia by the length of its septal necks; these are short in Cyrtoclymenia, yet longer (though not contiguous) in Platyclymenia. Schmidt (1924, fig. 4) only partially confirmed this. He showed Plat. subnautilina (annulata Zone) with a V-shaped dorsal lobe and short septal necks, Cyrt. involuta (delphinus Zone) with a broad shallow dorsal lobe and short septal necks, but Cyrt. lata (Clymenia Stufe) was shown as having a deeper dorsal lobe and long septal necks.

Bogoslovskiy (1976) illustrated a section through the initial whorls of Plat. richteri (Textfig. 4.2B,C). The diameter of the protoconch was 0.52mm and that of the embryonic shell 0.96mm, the body chamber being 285^{o} in length. Early septal necks are short and the siphuncle migrates from a position central in the whorl in the first septum to a normal dorsal position by the third septum.

The dorsal wrinkle-layer consists of closely spaced radial anastomosing striae. The ventral wrinkle-layer is unknown.

Included subgenera: Following Schindewolf (1934) four subgenera are recognised:

Platyclymenia	Hyatt 1884
Pleuroclymenia	Schindewolf 1934
Trigonoclymenia	Schindewolf 1934
Spinoclymenia	Bogoslovskiy 1960

Platyclymenia has a subcircular or compressed whorl section, Pleuroclymenia a depressed whorl section, Trigonoclymenia parabolic nodes, and Spinoclymenia has spines projecting from the ventro-lateral surface. Stenoclymenia, with a shallow ventral lobe, is treated as a separate genus.

Remarks: There have been many attempts at designation of a type species for this genus, and while Cl. annulata Münster has long been regarded as the type species authors have had difficulty pinning down where the earliest statement of this fact was made. _Platyclymenia_ was established by Hyatt (1884, p. 314) but through a typographical error, or otherwise, he did not use the same wording in assigning species to this genus as he had done with others and thus no type species was designated. It appears that the word "Type" was omitted from between "subquadragonal" and "_Platy. annulata_", which would then have made the description conform in style with Hyatt's others.

Hyatt's intention seems to have been to designate Gümbel's figure (1863, pl. XV, fig. 11) as the type for _Platyclymenia_, since this is first in the list of three species included within _Platyclymenia_ (the others were _Cl. spinosa_ and _binodosa_).

Gümbel (1863, p. 130) had given a long description of _Cl. annulata_ and included a number of other authors' figures in synonymy. He had said that a small fragment (pl. XV, fig. 11) was Münster's original. At first sight this statement may seem implausible since Münster's figure (1832, pl. VI, fig. 6) is of a whole specimen 35mm in diameter, from Regnitzlosau (Oberfranken), whereas Gümbel's is a fragment half this size from Schübelhammer (Oberfranken). However, Münster's original account states that the drawing was greatly enlarged and later (1839, p. 14) he qualified his earlier description by saying that this first figure was based on more than one fragment, and that it had been incorrectly stated that the specimens were collected from Regnitzlosau, rather than Schübelhammer. Newly collected specimens enabled him to say that the species was recognised to be a _Clymenia_ and that the whorl section was not rounded and quadrate, but rounded with equal whorl height and width. This revised description still gave no account of the suture.

In 1842 (p. 123, pl. XII, figs. 1a-c) Münster published another description of Cl. annulata, which differed significantly from the earlier accounts. Here were shown S-shaped ribs and a sickle-shaped Costaclymenia-type suture on a well preserved specimen. The rib shape alone would cause this specimen to be placed in a different family.

We can now accept that the specimen figured by Gümbel (1863, pl. XV, fig. 11), listed by Hyatt (1884) as an example of the genus and probably intended as the type, and the specimen figured by Münster (1832, pl. VI, fig. 6) are one and the same. This particular specimen, the lectotype, is lost; indeed no author since Gümbel has described it.

Discussion: Platyclymenia was introduced by Hyatt (1884) to accommodate evolute ribbed forms with simple sutures, comprising rounded lateral and dorsal lobes. Frech (1887a - 1913) did not use the genus Platyclymenia but merely defined its type in a footnote (1902). Other German accounts (e.g. Drevermann 1901, Wedekind 1908, Rzehak 1910, Born 1912a) also ignored it.

Wedekind 1908 introduced three genera, Rectoclymenia, Protactoclymenia and Varioclymenia, in all of which he included species which would now be assigned to Platyclymenia. These genera (in fact three "Gruppen" "Rectoclymeniae" etc. were defined (1908, p. 604-5) but later in the text the explicit terms "Gattung: Rectoclymenia" etc. were employed) were defined by their growth-lines and these definitions are paraphrased below. Wedekind failed to designate any type species, which hinders current interpretation.

Rectoclymenia:	growth-lines radial and concave during all growth stages.
Protactoclymenia:	Growth-lines with a more or less pronounced ventro-lateral salient.

Varioclymenia: growth-lines on the phragmacone have a pronounced ventro-lateral salient, but are radial on the body chamber.

Type species have subsequently been designated for two of the genera, and a type species is proposed for the third.

Varioclymenia, Wedekind 1914, p. 30: type species Varioclymenia pompeckji, which is an illegal emendation of Varioclymenia pompeckii Wedekind 1908, p. 607, pl. XLIII, figs. 4a, subsequently designated by Matern 1931, p. 97, (designation invalid, see Cyrtoclymenia below).
Rectoclymenia: Rectoclymenia roemeri Wedekind 1908, p. 613, pl. XLIII, fig. 9, subsequently designated by Matern 1931, p. 95, (but see Gen. Nov. D, below).
Protactoclymenia: Protactoclymenia pulcherrima Wedekind 1908, p. 608, pl. XLIII, figs. 13,a, designation proposed herein (see below).

Using these type species to define the genera only Varioclymenia falls within the Platyclymeniidae. Some of the species which authors placed in Varioclymenia are not now placed within the family e.g. kayseri Drevermann, wedekindi Born, sulcata Schindewolf.

Wedekind adopted the use of Platyclymenia in 1914 (p. 29) in his revision of the clymeniid faunas of the Rheinische Schiefergebirge, introducing at the same time numerous species and providing new generic diagnosis:

Platyclymenia: growth-lines concave over the flanks and with a sinus over the venter.
Varioclymenia: growth-lines biconvex, becoming straight on the body chamber of mature individuals

Schindewolf (1923a) dropped the use of Varioclymenia, but after submitting his text, assigned species to it in footnotes. He described more than twenty species of _Platyclymenia_. Both Wedekind and Schindewolf divided _Platyclymenia_ into six groups on the basis of shell form and ribbing, namely:

Group	Definition
Plat. rotundata:	rounded cross-section and ribs of even thickness
Plat. annulata:	flattened flanks with ribs thickening towards the venter.
Plat. bicostata:	flattened flanks with paired ribs
Plat. protacta:	parabolic ribs
Plat. intracostata:	ribs only on the earliest whorls
Plat. quenstedti:	ribs absent

Later Schindewolf (1923b) changed his conception of _Varioclymenia_ and _Platyclymenia_. He believed that _Varioclymenia_ was the precursor of _Platyclymenia_.

Varioclymenia:	concavo-convex growth-lines, lacking parabolic ribs
Platyclymenia:	concavo-convex growth-lines, with parabolic ribs

Lange (1929) interpreted _Varioclymenia_ as having growth-lines which were biconvex in early stages, becoming straight and lacking parabolic ribs. Because there was no sharp dividing line between presence and absence of parabolic ribs _Varioclymenia_ was separated only at subgeneric level. Lange also recognised that in certain early species the growth salient over the umbilico-lateral shoulder could be so slight as to give the impression that the growth-lines were concavo-convex.

Both Schindewolf and Lange acknowledged that many transitional forms existed between the species they recognised. In particular Lange realised that Wedekind's division of the genus into groups based on whorl cross-sectional shape was untenable. He preferred to use the nature of the ribbing as a distinguishing character, though even here there was no clear boundary between groups with or without parabolic ribs, nor those with or without paired ribbing.

Lange also introduced Stenoclymenia for clymeniids with a quadrate compressed whorl section, growth-lines which were concave, prorsiradiate with a ventro-lateral salient, and, most importantly, a suture consisting of ventral, lateral and dorsal lobes. The presence of a ventral lobe caused Lange to place this genus in his suborder Gonioclymeniaceae, rather than in Platyclymeniacea.

Clearly the question of variability could be solved only by examining a large number of individuals and Schindewolf (1934) collected around 480 specimens from trenches at Hauern (Wildungen, Kellerwald) which he used as a basis for a comparison between Platyclymenia from the Three Forks Shale (Montana) and European forms. His conclusions were, however, somewhat limited being restricted to a discussion of the three subgenera into which he divided Platyclymenia.

He introduced two new subgenera, defined as follows and summarised in a simple diagram, Textfig. 4.12

Platyclymenia:	concave ribs
Pleuroclymenia:	whorl cross-section depressed with straight radial growth-lines and broad shallow lateral and dorsal lobes
Trigonoclymenia:	with parabolic ribs

With the single exception of Nalivkina (1953) all subsequent authors have utilised this scheme.

In 1962 Bogoslovskiy introduced what he treated as an additional subgenus of Platyclymenia, Spinoclymenia. This was distinguished by the presence of spines developed on the ventro-lateral shoulders, projecting ventrally. Walliser (1966) realised that

Platyclymenia had been subject to taxonomic oversplitting when describing a small collection of Platyclymenia from Iran. He has postponed a thorough reconsideration of the genus until he has obtained more material.

There are a large number of specific names available. These are listed below.

Although most of the species of Platyclymenia were initially described from material collected at either Beil (Balve) or Kirch-Gattendorf, both of which are the concern of this thesis, I do not have sufficient material to make a decisive contribution towards integrating the large number of available specific names or charting their variation. At Beil the level yielding Platyclymenia has in recent years been trenched and intensively collected over nearly all its outcrop of 400m, making further collecting difficult. Comment will be restricted to a discussion of the few types I have encountered in examining museum collections.

Available specific names:

*	annulata	Münster 1832, p. 32, pl. VI, fig. 6, Schübelhammer, Oberfranken.
	alterna	Jenkins 1968, p. 543, pl. 105, figs. 8-11, Tamworth, New South Wales.
	arieticosta	Schindewolf 1923a, p. 459, pl. XIII, figs. 2a-b, textfig. 20, Kirch-Gattendorf, Oberfranken.
	beuelensis	Lange 1929, p. 101, pl. 3, fig. 28, textfig. 29, Beil, Sauerland.
	bicostata	Wedekind 1914, pl. 3, figs. 16,17,18 (holotype) by subsequent deisgnation of Matern 1931, Beil, Sauerland.
	bisulcata	Schindewolf 1923a, p. 445, Langenaubach.
	callimorpha	Lange 1929, p. 100, pl. 3, fig. 27, textfig. 28, Enkeberg, Sauerland.
	clarkei	Schindewolf 1923a, p. 452, pl. XVII, fig. 10, Bed 14, Kirch-Gattendorf, Oberfranken.

	correcta	Perna 1914, p. 75, pl. III, fig. 14, fig. 77.
	crassa	Schindewolf 1923a, p. 458, textfig. 19b, Bed 14, Kirch-Gattendorf, Oberfranken.
	curvidorsata	Sobolev 1912, p. 9, pl. IV, figs. 5-7, Lagow, Poland.
	cycloptera	Wedekind 1908, p. 610, pl. XLIII, figs. 11a, Enkeberg, Sauerland.
	decora	Kind 1944, p. 157, pl. 1, fig. 12, Mugozhar, USSR.
	denckmanni	Schindewolf 1923a, p. 450, pl. XVII, figs. 13a,b, Bed 14, Kirch-Gattendorf, Oberfranken.
	densicosta	Frech 1902, p. 31, pl. II(I), fig. 7, (lectotype, designated by Jenkins 1968 as Gümbel 1863, pl. XV, fig. 13).
	densicostata	Tokarenko 1903, pl. III, fig. 2,a,3, s. Urals.
	geminicostata	Petter 1960, pl. V, figs. 6,a, Ouarourout, Saoura Valley, Algeria.
	grossi	Müller 1960, p. 71, pl. 2, fig. 21, Schleiz, Thuringia.
	inostranzevi	Loewinson-Lessing 1892, p. 21, pl. II, figs. 2a-c, s. Urals.
	intracostata	Frech 1902, pl. II(I), fig. 8, textfig. 1c, La Serre, Montagne Noire.
	kasakstanica	Kind 1944, pl. 1, figs. 16,17,a, Mugozhar, USSR.
h	kasakstanica	Nalivkina 1953, pl. IV, figs. 4a,b, Mugozhar, USSR.
	mirabilis	Wedekind 1914, p. 45, pl. 3, fig. 6, Beil, Sauerland.
	nodosa	Gümbel 1863, p. 130, pl. XVIII, figs. 11a-d, Schübelhammer, Oberfranken.
	pattisoni	M'Coy 1851, p. 488, 1852, p. 403, pl. 21, figs. 11a,b, Landlake, Cornwall.
	placida	Perna 1914, p. 77, pl. III, figs. 13a,b, pl. IV, figs. 12,13a,b.
	pompeckii	Wedekind 1908, p. 607, pl. XLIII, figs. 4,a,5, Enkeberg, Sauerland.
	pseudoflexuosa	Rzehak 1910, pl. 181, pl. I, fig. 1a (holotype), b,c, pl. II, figs. 8,9, Brno, Czeckoslovakia.
	quenstedti	Wedekind 1914, p. 45, pl. 2, figs. 5a,b, pl. 3, figs. 10a,b, Beil, Sauerland.

quiringi	Müller 1956, p. 74, pl. 2, fig. 25, Schleiz, Thuringia.
raricosta	Schindewolf 1923a, p. 451, Bed 14, Kirch-Gattendorf, Oberfranken.
recticosta	Rzehak 1910, p. 180, pl. II, figs. 10a-c, Brno, Czeckoslovakia.
richteri	Wedekind 1914, p. 34, pl. 3, figs. 1a-c, Beil, Sauerland.
rotundata	Wedekind 1914, p. 34, pl. 2, fig. 15, Beil, Sauerland.
ruedemanni	Wedekind 1914, p. 46, pl. 2, figs. 1a-c, pl. 3, fig. 9, Beil, Sauerland.
rustica	Perna 1914, p. 76, pl. III, fig. 15, textfig. 78.
schleizi	Müller, 1956, p. 74, pl. 2, fig. 24, Schleiz, Thuringia.
semiornata	Petter 1960, p. 27, pl. V, figs. 12a, Erfoud (Tafilalet), Algeria.
semperornata	Petter 1960, p. 25, pl. IV, figs. 6,a, 11,a, Erfoud (Tafilalet), Algeria.
senilis	Lange 1929, p. 100, pl. 3, fig. 26, Enkeberg, Sauerland.
simplex	Kind 1944, p. 161.
subnautilina	Sandberger 1855, p. 5, pl. I, figs. 1a-f, Kirschofen, Weilburg.
teicherti	Jenkins 1966, p. 541, pl. 104, figs. 1-4, textfigs. 2a-j, Tamworth, New South Wales.
transita	Kind 1944, p. 161, pl. 1, figs. 18,a.
tschernyschewi	Rzehak 1910, p. 186 and Chernyshev 1887b, p. 18, pl. I, figs. 23-6.
varicatum	Sobolev 1914b, p. 373, pl. 9, figs. 33a,b, 34, Kielce, Poland.
walcotti	Wedekind 1914, p. 38, pl. 3, figs. 11a,b, Beil, Sauerland.

Subdivision of Platyclymenia into species groups:

Platyclymenia (Platyclymenia) can be split into two groups by shell shape:

annulata Group

Concave or straight, radial to slightly prorsiradiate ribs or growth-lines over the flanks, cross-section subcircular to quadrate compressed.

quenstedti Group

Prorsiradiate ribbing or growth-lines with ventral band and compressed quadrate whorl section.

The shape of growth-lines, ribbing and suture appear to be a function of shell cross-sectional shape. Thus forms with a subcircular cross-section have growth-lines with a relatively deep sinus on the flanks and venter. As the whorl cross-section becomes compressed and the flanks flattened the growth-lines become straighter and prorsiradiate with an increasingly deeper ventral sinus. Forms with increasingly depressed cross-sections have growth-lines and sutures which become more radial and straight, with a shallower ventral sinus (cf. _Pleuroclymenia_).

The other major varying character within _Platyclymenia_ is the ribbing strength and density. Generally where ribs are few they are strong and _vice-versa_. Some forms are smooth, others have ribbed inner whorls and smooth outer whorls, and yet others have ribs which remain throughout all growth stages. The combinations of these characters are best expressed in tabular form; see Lange (1929), and below.

The end-points of these apparently continuous morphological variants have been separated out by authors as distinct subgenera, thus _Pleuroclymenia_ grades into _Platyclymenia_, and _Stenoclymenia_ represents those variants of the _Plat_. _quenstedti_ group where the venter has become so flattened that the ventral saddle is expressed as a secondary shallow lobe. This effect can also be produced by polishing flat the rounded venter of a normal _Platy-clymenia_.

An attempt was made to examine the various species of _Platy-_

clymenia more objectively, to see if the groupings authors had made within it could be substantiated. Two characters were evaluated: the ratio WW/WH, which is an indication of the whorl cross-sectional shape, and the ornament, principally a simple rib count. The figures obtained were plotted in Textfig. 5.13. The type specimens alone were considered, and thus only 42 "species" appear on the plot. This is because data is lacking for the others or the types are missing, unillustrated or are too poorly preserved to show the features recorded. There is no stratigraphic control and the rib counts have not been made at similar diameters. For a more perfect comparison there should be plots based on examinations of large numbers of individuals from single populations, accounting also for ontogenetic variation in the whorl cross-section and ornament. Obviously if such samples were available more sophisticated multivariate analysis could be carried out.

The groupings in the table appear to validate the subjective divisions which have already been made by Schindewolf, Lange etc. These groups are:

1) with compressed rectangular whorl section

i) unribbed

arieticosta	Schindewolf
prorsistriata	Schindewolf
quiringi	Müller
schindewolfi	Lange
stenomphala	Lange
valida	Phillips (ss.)

ii) ribbed

clarkei	Schindewolf
intracostata	Frech
sandbergeri	Wedekind

2) with compressed subcircular to circular whorl section

i) unribbed

beuelensis	Lange
crassa	Schindewolf
placida	Wedekind
quenstedti	Wedekind
ruedemanni	Wedekind

ii) ribbed, densities between 15 and 40 per whorl

a) annulata	Münster
bicostata	Wedekind
densicosta	Frech
semperornata	Petter
valida sensu	Wedekind
walcotti	Wedekind
b) mirabilis	Wedekind
nodosa	Münster
pompeckii	Wedekind
richteri	Wedekind
rotundata	Wedekind
rustica	Perna
semiornata	Petter

3) depressed whorl section

i) ribbed

americana	Raymond
brevicosta	Wedekind
crassissima	Schindewolf
polypleura	Raymond

Group 1i comprises species of Stenoclymenia.

Group 1ii and 2 comprise species of Platyclymenia.

Group 3 comprises species of Pleuroclymenia.

No defence is made for the taxonomic usage of all species listed, they are merely names for particular morphologies to assist in discussion. Short diagnoses are given for the species listed in the table, mostly translations from authors' original descriptions.

In many cases lectotypes etc. are undesignated and the opportunity is taken to propose them. Measurements are listed in the order diameter, umbilical width, whorl width, whorl height. Where it is known the collecting horizon, locality and museum in which the specimen is now housed are given.

<u>annulata</u>	Münster 1832, p. 32, pl. VI, fig. 6 (= Gümbel, 1863, pl. XV, fig. 11, lectotype, designation proposed here). Neotype (designation proposed herein), Pl. 5.12, Fig. 8, Mbg, (dimensions below) from Bed 14 Kirch-Gattendorf, Oberfranken. Densly ribbed <u>Platyclymenia</u> with quadrate compressed whorl section.				
		26.8	14		7
<u>beuelensis</u> (<u>ruedemanni</u> var.)	Lange 1929, p. 101, pl. 3, fig. 28, from "1 metre above the fossil rich bed", Beil. Flanks more strongly curved than on <u>ruedemanni</u>, and the venter more flattened.				
		38	16.5	10.5	11.5
<u>bicostata</u>	Wedekind 1914, p. 38, pl. 3, figs. 16,17a,b,18a,b, (lectotype, designated by Matern 1931, p. 100) ? 19 (not listed in text). Figs. 16 and 17 are at Menden, the rest are untraced. Thinly discoidal, widely umbilicate with ribs arranged in two's or three's.				
		25	13	7	7
<u>callimorpha</u>	Lange 1929, p. 100, pl. 3, fig. 27 (holotype) Enkeberg. Narrower umbilicus than <u>pompeckii</u>.				
		20	9	7.5	6
<u>clarkei</u>	Schindewolf 1923a, p. 459, pl. XVIII, fig. 10 (lectotype, Mbg 3128, proposed herein) from Bed 14				

Kirch-Gattendorf.
Thinly discoidal, widely umbilicate with a quadrate whorl section. Pl. 5.12, Figs. 1,2.

25	12		

<u>crassa</u> (<u>quenstedti</u> var.) — Schindewolf 1923a, p. 458, textfig. 19b (lectotype, Mbg 3152, proposed herein) Bed 14 Kirch-Gattendorf. Lacking ornament and with a more circular cross-section than <u>quenstedti</u>.

32	14.8	9.3	9.0

<u>crassoides</u> — Matern 1931, p. 102, footnote 1. Invalid substitution for <u>Plat</u>. <u>quenstedti</u> var. <u>crassa</u> Schindewolf 1923a, which is a senior homonym of <u>Plat</u>. <u>crassa</u> Schindewolf 1923a (see <u>Pleur</u>. <u>crassissima</u>, below).

<u>cycloptera</u> — Wedekind 1908, p. 610, pl. XLIII, figs. 11a, (lectotype, Göttingen) Beds 10 or 12 at Enkeberg. Fine ribs, whorl section depressed, becoming compressed in later whorls.

21.5	9.5	7.2	7.0

<u>denckmanni</u> — Schindewolf 1923a, p. 450, pl. XVII, figs. 13a,b, (holotype proposed herein). Recorded as from Bed 14 Kirch-Gattendorf, but since Schindewolf did not collect this specimen it is difficult to see how he could have determined the horizon. Pl. 5.15 Figs. 6,7.
Paired ribs with whorl width and height equal, flattened flanks and wide umbilicus.

18	7.5	6	6.5

<u>densicosta</u> — Frech 1902, p. 31, pl. II(I), fig. 7, Enkeberg, untraced. Neotype, Göttingen, proposed herein, Wedekind 1914, p. 36, pl. 3, figs. 2a,b, from Ense.
Defined by Frech as having "close ribs", and by Wedekind as quadrate with strong angular ribs at

all stages. At a diameter of 20mm ribs have a spacing of 2.5mm.

	28	13	9.2	8.9

h <u>densicosta</u> (<u>richteri</u> var.) — Wedekind 1914, p. 35.
Never illustrated, defined simply as having denser ribbing.

<u>grossi</u> — Müller 1956, p. 71, pl. 2, fig. 21 (holotype MfN 5522), Bed 3B Alte Heerstrasse, Schleiz. Widely umbilicate with 10 ribs per whorl, circular whorl section, becoming compressed.

	15	9	3.5	-	A 4

<u>intracostata</u> — Frech 1902, p. 32, pl. II(I), fig. 8, La Serre, Montagne Noire. Type material is presumed to have been destroyed at Wrocław.
Smooth outer whorls, possibly with converging flanks.

<u>mirabilis</u> — Wedekind 1914, p. 45, pl. 3, figs. 10a,b (lectotype ? Göttingen) designated by Matern 1931, p. 102, pl. 2, figs. 5a,b, Beil.
Widely umbilicate with oval whorl section and no radial ribs.

lt	57	25	16	19.2
	36.5	17.6	9.5	11.7

<u>nodosa</u> — Münster 1839, figured by Gümbel 1863, p. 47, pl. XVIII, figs. 11a-c (lectotype BSP AS VII 606 proposed herein), Schübelhammer, Oberfranken.
Outer whorls smooth with radial S-shaped growth-lines and converging flattened flanks.

<u>pattisoni</u> — M'Coy 1851, p. 488, 1852, p. 403, pl. 2A, fig. 11 (holotype SM H990, Pl. 5.16, Figs. 5,6) Lower Petherwin Beds, Landlake, Launceston.
Smooth compressed whorls.

	20	9.5	5	7

Selwood (1960) made this species the senior synonym of Cl. subnautilina and followed Schmidt (1922) in making that species a senior synonym of Platyclymenia quenstedti. Neither opinion is correct since Plat. subnautilina has weak ribbing (see below). Plat. pattisoni is too poorly preserved to be compared with Plat. quenstedti and is regarded as a nomen dubium.

pompeckii — Wedekind 1908, p. 607, pl. XLIII, figs. 4,a (lectotype, Göttingen, designated by Matern 1931, p. 99). Beds 12 or 13, Enkeberg.
Circular cross-section, strong radial ribs and biconvex growth-lines at middle sized diameters. Type species of Varioclymenia Wedekind.

	47.5	25.5	15	13

pseudoflexuosa — Rzehak 1910, p. 181, pl. 1, fig. 1 (proposed here as the lectotype), pl. II, figs. 8,9, Haidenberg, Brno.
Faint ribs, smooth body chamber with flattened converging flanks.

	67	28	-	23
	47	18	11.8	16

quenstedti — Wedekind 1914, p. 45, pl. 3, figs. 10a,b (lectotype, Göttingen, designated by Matern 1931, p. 102) pl. 2, figs. 5a,b, Beil.
Widely umbilicate, oval whorl section and prorsiradiate bunched concave growth-lines and ventral band. Pl. 5.14.

lt	57	25	16	19.2
	36.5	17.6	9.5	11.7

quiringi — Müller 1956, p. 74, pl. 2, fig. 25 (holotype, MfN 5526) Bed 3A Alte Heerstrasse, Schleiz.
Extremely widely umbilicate, flatly discoidal without ribbing, and slowly increasing whorls.

	24.5	12	3.5	5.5

raricosta	Schindewolf 1923a, p. 451, (holotype, Mbg, recognised here and figured Pl. 5.16, Fig. 1) Bed 14 Kirch-Gattendorf. Paired ribs in early whorls, and widely spaced ribs in outer whorls.
recticosta	Rzehak 1910, p. 180, pl. II, figs. 10a-c (holotype recognised herein), Haidenberg, Brno. Smooth inner whorls, subsequently developing ribs. Oval whorl section.
	43.5 15.4 12.3 14.1
richteri	Wedekind 1914, p. 34, pl. 3, fig. 1 (lectotype Menden, designated by Matern 1931, p. 99), Beil. Very strong ribs on the inner whorls and widely spaced on the outer whorls, where whorl section becomes compressed. Pl. 5.12, Fig. 6.
	60 27.7 17.7 20
rotundata	Wedekind 1914, p. 34, pl. II, fig. 15 (lectotype Göttingen, designated by Matern 1931, p. 99), Beil. Curved flanks present up to a diameter of 40mm, with prorsiradiate concave growth-lines.
ruedemanni	Wedekind 1914, p. 46, pl. 2, fig. 1a-c (lectotype designated by Matern 1931, p. 103), Beil. Widely umbilicate with flattened flanks and no ribbing.
	76.2 32.4 ca23 ca21.0
	55.9 21.5 16.7 20
	27.3 11.5 7.5 8.5
schleizi (subnautilina)	Müller 1956, p. 74, pl. 2, fig. 24 (holotype, MfN 5525) Bed 3A Alte Heerstrasse, Schleiz. Widely umbilicate with straight growth-lines, which run together to form a ventral band.
	15 7.5 5.0 5.0
semiornata	Petter 1960, p. 27, pl. IV, figs. 12,a (holotype

proposed herein), Erfoud, Algeria.
Similar to *ruedemanni* but with ribbed inner whorls.

28 14 8.0 8.5

semperornata (*richteri* var.) Petter 1960, p. 25, pl. IV, figs. 6,a, 11,a (lectotype proposed herein), Erfoud, Algeria.
Similar to *richteri* but with 32 ribs instead of 25.

lt 54 27 15 15
21 11.5 7 5

senilis (*pompeckii* var,) Lange 1929, p. 100, pl. 3, fig. 26 (holotype), Enkeberg.
Differ from *pompeckii* in developing flattened flanks earlier.

27 12.5 9 8

subnautilina Sandberger 1855, p. 5, pl. I, figs. 1a-f (lectotype, Wsb, and syntype proposed here as Pl. 5.15, Figs. 9 and 8 respectively), Kirschofen, Weilburg.
Sandberger's figure is based on the lectotype, but the ornament of the inner whorls and the patch of shell near the aperture are based on the syntype.
Inner whorls weakly ribbed with faint S-shaped ribs on the body chamber.

walcotti Wedekind 1914, p. 38, pl. 3, fig. 11 (lectotype, Menden, proposed herein), Beil.
Fine widely spaced ribs on the inner whorls flatly discoidal and widely umbilicate. It has a curved venter and single ribs at the aperture which distinguish it from *bicostata*.

37.2 17.6 9 11

Horizon and distribution: *Platyclymenia* is the most widely distributed clymeniid, being known from Cornwall (England), Rheinische Schiefergebirge, Harz, Thuringia, Oberfranken, Saxony (E. and W. Germany), Holy Cross Mountains (Poland), Brno (Czechoslovakia), Montagne Noire (France), Carnic Alps (Austria-Italy),

s. Urals, Kazakhstan (USSR), Pakistan, Great Khinghan (China), Canning Basin, New South Wales (Australia), Alberta (Canada) and Montana (USA).

Most authors have reported the genus from the delphinus and annulata Zones, but Bogoslovskiy (1979b) extended its range into the lower half of the Clymenia Stufe.

Subgenus Platyclymenia (Platyclymenia) Hyatt 1884

Textfigs. 5.12-14

Type species: as for genus.

Diagnosis: Platyclymenia with concave ribs, lacking spines or parabolic tubercles.

Horizon: Platyclymenia Stufe.

Platyclymenia (Platyclymenia) annulata (Münster 1832)

Pl. 5.12, Figs. 1-5,8, Textfigs. 5.12M,N

*	1832	Goniatites annulatus sp. nov. - Münster, p. 32, pl. VI, fig. 6.
	1834	Goniatites annulatus Münster - Münster, p. 95, pl. VI, fig. 4 (copy of Münster's 1832 figure).
	1839	Clymenia annulata Münster - Münster, p. 14.
non	1842	Clymenia annulata Münster - Münster, p. 123, pl. XII, figs. la-c.
	1843	Clymenia annulata Münster - Münster, p. 25, pl. VIa, fig. 6 (copy of Münster's 1832 figure).
p.	1863	Clymenia annulata Münster - Gümbel, p. 130, pl. XV, figs. 11a-d, only.
non.	1901	Clymenia annulata Münster - Drevermann, p. 132, pl. XIV, figs. 5,a,7,a.

non. 1902 Clymenia annulata Münster - Frech, p. 31, pl. II(I), figs. 6a-c.

1902 Clymenia annulata var. densicosta nov. - Frech, p. 31, pl. II(I), fig. 7.

(?) 1914 Platyclymenia annulata Münster - Wedekind, p. 35. Platyclymenia annulata var. densicosta Frech - Wedekind, p. 36, pl. III, figs. 2a-b.

pv 1923a Platyclymenia annulata Münster - Schindewolf, p. 447, pl. XVII, fig. 7, non fig. 8.

v 1923a Platyclymenia annulata var. densicosta Frech - Schindewolf, p. 449.

non. 1929 Platyclymenia annulata Münster - Lange, p. 107.

1929 Platyclymenia annulata Münster - Lange, p. 108.

non. 1956 Platyclymenia (Platyclymenia) annulata (Münster) - Müller, p. 70.

non. 1960 Platyclymenia annulata (Münster) - Petter, p. 23, pl. IV, figs. 4,7,9,10, textfig. 3E.

non. 1968 Platyclymenia (Platyclymenia) annulata annulata (Münster) - Jenkins, p. 503, pl. 104, figs. 5,6.

? 1968 Platyclymenia (Platyclymenia) annulata densicosta Frech - Jenkins, p. 540, pl. 104, figs. 7,8.

Type material: A neotype (Mbg) illustrated in Pl. 5.12, Fig. 8, from Bed 14, Kirch-Gattendorf, Oberfranken, (see Schindewolf 1923a) is proposed. No syntype material could be traced.

Remarks: Gümbel's figure (1863, pl. XV, fig. 11) of Münster's original of G. annulatus (1832, pl. VI, fig. 6), embellished and enlarged when he figured it (see above, Genus Platyclymenia, Münster 1839, p. 14 and Gümbel 1863, p. 130) is regarded as the lectotype. The selection by Wedekind (1914), Schindewolf (1923a), Lange (1929) and Jenkins (1968) of another of Gümbel's figures (pl. XV, fig. 12), a specimen from Planitz (Saxony) in Geinitz' Collection, as "Typus" was invalid, since that specimen is not from the type series. The figures of the juvenile lectotype are insufficient for its accurate interpretation and therefore it is proposed that a neotype be selected from material from Kirch-Gattendorf, which is near to the type locality.

Diagnosis: Platyclymenia (Platyclymenia) with quadrate to subcircular compressed whorl section, and rounded to flattened flanks and venter. Ribs are closely spaced at all diameters and are sometimes paired on the inner whorls.

Description: Four specimens were studied, the neotype, and three others from Bed 14 at Kirch-Gattendorf. All are housed at Marburg, and are illustrated in Pl. 5.12.

The neotype (Fig. 8) is evolute, with an umbilical width about 50% of the diameter. The whorl section is rounded in early whorls, becoming quadrate with flattened flanks and venter. At a diameter of ca 3mm there are periodic fine lirate growth-lines, which develop into strong sharp ribs by a diameter of ca 10mm. There are approximately fifteen ribs in the half whorl up to a diameter of 5mm, and this frequency is maintained up to a diameter of 20mm. Near to the aperture the ribs are diminished in strength and packed twice as closely. The ribs never continue over the venter.

Two other specimens of <u>Plat</u>. (<u>Plat</u>.) <u>annulata</u> from Bed 14 are illustrated here. These are Mbg 3125 (Pl. 5.12, Figs. 3,4, Textfigs. 5.13M.N) and Mbg 3128 (Pl. 5.12, Figs. 1,2). The former, figured by Schindewolf 1923a, pl. XVII, fig. 7, as <u>Plat</u>. <u>annulata</u>, has slightly different ribbing. The inner whorls have ribs which are wider spaced, there being ca 25 per whorl up to a diameter of 15mm, and the ribs themselves are wider. The last whorl, up to a diameter of 30cm, has finer ribs with a closer spacing, numbering ca. 50 in the last half whorl.

The other figured specimen is the lectotype of <u>Plat</u>. <u>clarkei</u> Schindewolf, apparently distinguished by its wider umbilicus, and paired ribs on the inner whorls. The umbilical width is no different from <u>Plat</u>. <u>annulata</u>, and the presence of paired ribbing is not considered to be a specifically diagnostic character.

Discussion: Münster's first illustration of <u>G</u>. <u>annulatus</u> (1832, pl. VI, fig. 6) was a reconstruction, the extent of which has been demonstrated by Gümbel (see Genus <u>Platyclymenia</u>, above), who figured what he believed to be the same specimen (1863, pl. XV, figs. 11a,b). Subsequent authors (Wedekind 1914, Jenkins 1968) ignored this information. Drevermann (1901, p. 132) included Gümbel's figures in synonymy, and figured two examples, 7 and 15mm in diameter, from Langenaubach (pl. XIV, figs. 5,a,7,a), which can now be identified as <u>Trigonoclymenia</u> sp.

Frech (1902) further confused the interpretation of this species by figuring (pl. II(I), figs. 6a-c) examples from Enkeberg and Beringhausen. One complete example had a subcircular whorl section, a diameter of 28mm and ca 20 ribs in the last whorl. Inner whorls appear to have ribbing only half as dense as in Gümbel's figure 11. At the same time he introduced another name, var. <u>densicosta</u>, for a variety with closely packed ribs, and gave as examples of this a figure of a fragment showing only six ribs (pl. II(I), fig. 7) and a reference (pl. XV, fig. 15) to a figure of a specimen from the Fichtelgebirge, "Gümbel Pl. XV, Fig. 15", which doesn't exist. Rzehak (1910, p. 170) drew attention to the differences between Frech's new interpretation of <u>Cl</u>. <u>annulata</u>, and the figures of Gümbel and Münster, saying that Frech's cross-section was far too rounded, unlike the quadrate sections reported by Gümbel (figs. 12,13), Cherynshev (1887b, pl. 1, figs. 11-16) and Wedekind (1908). He figured several specimens from Brno.

Wedekind (1914) recognised the broad way in which <u>Plat</u>. <u>annulata</u> ("der typischen Art") had been interpreted and redefined it as having a square whorl section flattened flanks and widely spaced ribs. However, he did not provide an illustration. He stated that he had been unable to trace Münster's original and based his interpretation on Gümbel's illustration (1863, pl. XV, fig. 12). This was a specimen from Planitz (Saxony) which Geinitz had figured (1853, pl. IX, fig. 4, (<u>fide</u> <u>auctt</u>.)) as <u>Cl</u>. <u>dunkeri</u>.

Schindewolf (1923a, p. 447) followed Wedekind's opinion and stated explicitly that he regarded Gümbel's fig. 12 as the type, because he thought it was uncertain whether the two figures provided by Gümbel and Münster, which purported to be of the same specimen, were identical. Authorship was therefore attributed to Gümbel. This course of action, resulting in the interpretation _Platyclymenia_ _annulata_ Gümbel, lectotype pl. XV, fig. 12, could only be accepted if two conditions were to have been fulfilled: that Gümbel was creating a new genus, and that he was clearly interpreting _annulata_ in a different way from its original author. In fact no new genus was being established and the interpretation was unchanged since Gümbel included in synonymy a figure of what he thought was Münster's original. Hence the above statement that Schindewolf's designation was invalid.

Schindewolf figured photographically two specimens as _Plat._ _annulata_ (1923a, pl. XVII). One (fig. 8) was from Langenaubach, and the other (fig. 7) from Kirch-Gattendorf. Both of these are illustrated here (Pl. 5.12, Figs. 9-12; 3,4, respectively).

Lange (1929) and Matern (1931) also recognised Gümbel's fig. 12 as the type. Lange was the first person to attempt to described precisely the ribbing and whorl cross-section of _Plat._ (_Plat._) _annulata_, which he did in tabular form:

	D	U	WW	WH	Ribs
annulata	10.3	5.5	3.7	3.0	21, 17
Lange 1929, p.108	30.5	13.3	8.8	10.0	17
	34.5	16.0	10.0	10.7	-
	61.0	28.0	ca17.0	20.0	-
densicosta	18.0	8.5	6.0	5.6	29
Lange 1929, p.108	38.5	12.2	ca11	12.2	31, 28

The only differences lay in the ribbing, with _densicosta_ possessing almost 50% more ribs at comparable diameters. However, introduction of similar figures for the specimens he regarded as types (marked below with an asterisk) clouds the easy distinction that Lange drew between Plat. annulata and densicosta, since the number of ribs (annulata 26,28; densicosta 25,34) falls between the values which Lange thought were typical for both species.

	D	U	WW	WH	Ribs	
annulata						
Schindewolf 1923a, pl. XVII						
fig.7 (distorted)	28	16	7	7	ca60,	ca25
fig.8	20				-	ca23
* Gümbel 1863, pl.XV						
fig.12	39	20	8	11	26,	28
fig.13	26				28,	24
densicosta						
* Wedekind 1914, pl. 3, fig. 2	28	13	7.2	8	34,	25

The lectotype of Plat. (Plat.) annulata, interpreted from Gümbel's figure, has at a diameter of ca 10mm ca 11 ribs in one third of a whorl, and thus would be placed in densicosta by Lange etc. The lectotype of Plat. (Plat.) densicosta has six ribs on a fragment, the angular length of which is difficult to estimate. Gümbel's figure 12 is listed above, as are the specimens figured by Wedekind and Schindewolf.

In 1934, when he revised the genus Platyclymenia, Schindewolf stated that Münster's original (1832) figure was to be regarded as the type of Plat. annulata. This view was repeated in the Treatise (Schindewolf 1957).

The last contributor to this discussion was Jenkins (1968), who adopted a dogmatic approach. He regarded Wedekind's (1914) use of Gümbel's fig. 12 as the basis for his description as a neotype designation for Plat. (Plat,) annulata annulata. Such a view is untenable; Wedekind employed a very flexible usage of the concept of "Typus" compared with modern (Code, 1961) definition and I am sure he had no understanding of the meaning of neotype, especially in the strict interpretation available to Jenkins. In short Jenkins has tried to wring as much as possible from statements written fifty years ago when a different philosophy prevailed. He excluded Gümbel's fig. 11 (= Münster 1832, pl. VI, fig. 6) from synonymy and selected Gümbel's fig. 13 as the lectotype for _Plat_. _annulata_ _densicosta_, assuming, presumably, that this was the specimen Frech had meant when he had erroneously written fig. 15 (see above).

To accept Gümbel's figs. 12 and 13 as types of two subspecies would leave little room for distinction (see rib count above). Jenkins stated that 26 ribs was to be the dividing line. However, we do not have to use as types the two specimens stated by Jenkins. Wedekind certainly did not select a neotype for _Plat_. _annulata_ and Gümbel's fig. 13 is not available for selection as the lectotype of _Plat_. _Plat_. _densicosta_, since it was not included in the type series.

As things stand only one figure (Gümbel fig. 11) is available for selection as the lectotype of _Plat_. _annulata_ (for fig. 12 to be available Hyatt would have had to have excluded fig. 11 in giving examples of what could then have been regarded as _Platyclymenia_ gen. nov. Hyatt _annulata_ sp. nov. Hyatt). Also only one figure (Frech's fig. 7) is available for designation as the holotype of _densicosta_ Frech. Both are inadequate for clear definition and neither can be traced, which is why the confusion outlined above has arisen. Thus there is justification for choosing neotypes. In selecting these an attempt has been made to conform with the authors' original figures and with the interpretations of subsequent workers. The material available has also exercised a constraint.

The particular specimen (Pl. 5.12, Fig. 8) proposed as the neotype for Plat. (Plat.) annulata is selected because it comes from near the type locality of G. annulatus and because it closely resembles Münster's figure. This interpretation is at variance with the opinions of some German workers (e.g. Lange) but is maintained because there seems to have been no agreement amongst these authors, simply because so few illustrations of Plat. annulata were ever published (viz. Frech 1902, pl. II(I), fig. 6, later interpreted by Wedekind as Plat. rotundata; Drevermann 1901, pl. XIV, figs. 5,7, which are two juveniles; Rzehak 1910, pl. II, figs. 1-5, most of which are excluded by Schindewolf 1923a, Lange 1929, etc.; Schindewolf 1923a, pl. XVII, figs. 7,8, discussed below). It is all the more important to define this species since it is currently used as the index fossil for the upper part of the Platyclymenia Stufe, although I believe that authors have used Schindewolf 1923a, pl. XVII, fig. 8 (= Pl. 5.12, Figs. 9-12) as their model, which is in fact Plat. (Plat.) richteri.

The neotype came from Bed 14 at Kirch-Gattendorf and bears the label Plat. annulata densicosta in Schindewolf's handwriting. The specimen in Fig. 5 was also similarly labelled. They are less densely ribbed. Bed 14 was recorded as a 2.40m thick limestone (1923a, p. 256), and from it Schindewolf recorded (p. 285) no less than 18 species of Platyclymenia, namely:

rotundata Wedekind	valida Phillips
* annulata Gümbel	* quenstedti Wedekind
densicosta Frech	* crassa sp. nov.
walcotti sp. nov.	ruedemanni Wedekind
* raricosta sp. nov.	* arieticosta sp. nov.
bicostata Wedekind	barrandei Wedekind
* clarkei sp. nov.	spinosa Münster
* denckmanni sp. nov.	dorsocava sp. nov.
intracostata Frech	protacta Wedekind

Because of the thickness of Bed 14 these cannot have been collected from one population but it is tempting to regard half of these (left-hand column) as synonyms, for they differ only slightly in rib density and whorl cross-sectional shape. To these could be added several other species which Wedekind (1914) introduced, namely:

mirabilis
richteri
richteri var. _densicosta_
valida sensu Wedekind, non Phillips

Initially comment will be restricted to those species marked with an asterisk, which are illustrated here. Dimensions of these species were given above.

Most of the specimens collected at Kirch-Gattendorf are distorted, flattened and often the dissolved shell has been replaced by a chloritic film on a stylolitic surface. A specimen Schindewolf interpreted as _Plat_. _annulata_ from Bed 14 (Pl. 5.12, Figs. 3,4) differs from the neotype of _Plat_. (_Plat_.) _annulata_ in having less densely, more strongly ribbed inner whorls. By contrast its outer whorls are densely ribbed. More different however, is the other specimen which Schindewolf interpreted as _Plat_. _annulata_. This was from Langenaubach, and is discussed with Wedekind's species from the Rheinische Schiefergebirge, below.

There appears to be no difference between the lectotype of _Plat_. _clarkei_ Schindewolf (Mbg 3128, Pl. 5.12, Figs. 1,2, proposed herein) and _Plat_. (_Plat_.) _annulata_. Schindewolf asserted that _Plat_. _clarkei_ was distinguished from _Plat_. _walcotti_ by a wider umbilicus. This is difficult to substantiate since the specimen is both incomplete, and distorted. _Platyclymenia raricosta_ (Pl. 5.16, Fig. 1) is too poorly preserved to be treated other than as a _nomen dubium_; it may be a _Plat_. (_Trigonoclymenia_).

Wedekind (1914) described a number of species of Platyclymenia from the Rheinische Schiefergebirge, details of which were tabulated above (see Platyclymenia). Three species, mirabilis, rotundata and valida sensu Wedekind, are very similar to the neotype of Plat. annulata, and differ only in their whorl cross-sectional shape, being more nearly circular. Wedekind's interpretation of Plat. valida, based on the interpretation of Drevermann (1901) was false, and especially so when Phillips' original and accurate figure is compared with it (Pl. 5.16, Figs. 7,8, Textfig. 5.12I). A specimen from Schleiz (Pl. 5.16, Fig. 9) figured by Müller (1956) is illustrated to demonstrate the German use of the name valida Phillips. For a current diagnosis of that species see under Stenoclymenia, below.

Two species, walcotti and bicostata, were established by Wedekind for examples with paired ribs; walcotti was distinguished by the presence of single ribs near the aperture and a curved venter. Paired ribs are a common feature of many Platyclymenia and are not considered to be a diagnostic character.

Platyclymenia richteri (see below) is one of the better defined of Wedekind's species, being based on an example 60mm in diameter. It has strong widely spaced ribs on the inner whorls, which become closer spaced and weaker on the body chamber. The specimen (Mbg 3126, Pl. 5.12, Figs. 7,9-12) figured by Schindewolf (1923a, pl. XVII, fig. 8) from Langenaubach is considered to belong to this species. Platyclymenia denckmanni (Pl. 5.15, Figs. 6,7) may belong here also. A specimen of Plat. (Plat.) richteri from Ainkhausen is illustrated in Pl. 5.13, Figs. 3,4,5,8,12. This represents what I believe stratigraphers have used to define the annulata Zone in the Rheinische Schiefergebirge. The ribs are stronger than Plat. (Plat.) annulata and more widely spaced.

This specimen, and the one figured by Schindewolf demonstrates a feature that was remarked on by Lange (1929), namely how difficult it is to separate specimens with and without parabolic ribbing. There are no prominent ears, as are developed on Plat. (Trig.) spinosa, but in places the ribs and growth-lines are convergent. This feature is especially visible on Pl. 5.12, Fig. 7, Textfig. 5.12L in the last whorl where the ribs extend onto the ventral margins and clearly cut across the growth-lines. Wedekind's variety of Plat. richteri densicosta cannot be interpreted because of the lack of a description or illustration.

At the opposite end of the spectrum from Plat. (Plat.) annulata Plat. (Plat.) subnautilina shows only rudimentary ribs on its inner whorls and Plat. beuelensis Lange and Plat. ruedemanni are totally lacking in ribs. Platyclymenia densicosta is considered as a synonym of Plat. annulata, as may be Plat. valida sensu Wedekind (see above), which has even more ribs. Platyclymenia quenstedti has distinctive prorsiradiate, bunched concave growth-lines and possesses a ventral band.

Until more collecting is undertaken from various levels within the annulata Zone no further advances can be made in the understanding of this group of Platyclymenia. Therefore, none of the names used are accorded a systematic position, except for Plat. (Plat.) annulata, richteri, nodosa, subnautilina, ruedemanni and quenstedti.

Specimens figured in the literature from outside Oberfranken can also be included within Plat. annulata. These are Plat. densicosta (Wedekind 1914, pl. III, fig. 2a) and three with more circular whorl sections and closer spaced ribbing: Plat. valida (Wedekind 1914, pl. III, figs. 3a,4), Plat. rotundata (Wedekind 1914, pl. II, fig. 15) and Plat. mirabilis (Wedekind 1914, pl. III, fig. 6a).

Comparisons: The closest species is *Plat. richteri*, with fewer stronger ribs in the inner whorls and a smooth body chamber. This is described below.

Horizon and distribution: *Platyclymenia* (*Plat.*) *annulata* is widely reported in the literature, from south west England to the southern Urals, Algeria, Iran, the Khingan Mountains of China and south eastern Australia. For the most part these reports are unhelpful because of the lack of a clear diagnosis of *Plat.* (*Plat.*) *annulata*. Interpretation appears to have been based on Schindewolf's figure (1923a, pl. XVII, fig. 8) of a specimen from Langenaubach. This is discussed below under *Plat. richteri*.

This species is the index fossil for the *annulata* Zone of Germany. It could be proposed that this zone be renamed the *richteri* Zone since most reports of *Plat. annulata* have probably been of this species. There would probably be considerable opposition from stratigraphers to such a proposal because the *annulata* Zone is firmly embedded in the literature. The only way to reconcile the continued usage of the name *annulata* Zone would be to apply to the ICZN to designate Mbg 3126 (Schindewolf 1923a, pl. XVII, fig. 8) as the neotype of *Plat.* (*Plat.*) *annulata*.

Platyclymenia (*Platyclymenia*) *richteri* Wedekind 1914

Pl. 5.12, Figs. 6,7,9-12, Pl. 5.13, Figs. 1-5,8,12, Textfig.5.12K,L

v*	1914	*Platyclymenia richteri* sp. nov. - Wedekind, p. 34, pl. 3, fig. 1.
v.	1923a	*Platyclymenia annulata* Gümbel - Schindewolf, p. 447, pl. XVII, fig. 8.
	1929	*Platyclymenia richteri* Wedekind - Lange, p. 111.
	1929	*Platyclymenia annulata* Gümbel - Lange, p. 107.

1931 Platyclymenia richteri Wedekind - Matern, p. 99.

. 1960 Platyclymenia richteri Wedekind - Petter, p. 25, pl. IV, figs. 13,a.

. Platyclymenia annulata var. densicosta Frech - Petter, p. 24, pl. IV, fig. 5, pl. V, figs. 13,a, 23.

. Platyclymenia annulata (Münster) - Petter, p. 23, pl. IV, figs. 4,a,7,a,9,a,10,a, textfig. 3E.

Type material: The lectotype from Beil (subsequently designated by Matern 1931, p. 99) was figured by Wedekind 1914, pl. III, figs. 1a-c, and is now housed in the Staatsmuseum Menden.

Diagnosis: Platyclymenia (Platyclymenia) with circular cross-section in earlier whorls, becoming quadrate. Inner whorls have strong widely spaced ribs which diminish in strength on later whorls, culminating in a body chamber with only weak indications of slightly concave ribs.

Description: Besides the lectotype (Pl. 5.12, Fig. 6) specimens examined include examples from Wäschholz (Oberfranken) (Pl. 5.12, Figs. 7-12, Pl. 5.13, Figs. 5,8,12), Langenaubach and Ainkhausen (Rheinische Schiefergebirge).

The lectotype has its inner whorls obscured by matrix. There are 15 blunt ring-like ribs in the whorl up to a diameter of ca 20mm, followed by a further 15 in the next half whorl, to a diameter of ca 30mm. The ribs are concave and persist to just over the ventro-lateral shoulder. In the last whorl seen the ribs gradually diminish in strength. The whorl section at a diameter of 30mm is quadrate, with flattened, slightly rounded flanks and a rounded venter.

The small specimen from Wäschholz (Pl. 5.13, Fig. 2) has narrow, paired ribs to a diameter of 10mm, which are succeeded by single ribs which are less strong than on the lectotype. A well preserved specimen (HU P82.3) was collected from a loose block (see Chapter 7) at Ainkhausen (Pl. 5.13, Figs. 1,3-5,8,12).

This shows well the ribbing of the innermost whorl (Fig. 12). Even at these small diameters some of the ribs cross cut the growth-lines. The rib density on this specimen is far less than on the lectotype, there are twenty ribs arranged in pairs in the whorl prior to a diameter of 20mm, and at this point the ribs begin to diminish in strength, and are barely present on the later stages of the body chamber. The flank ribs are reflected on the internal mould, as well as shallow sinuses over the venter. At a diameter of 20mm there was a break in the shell (Figs. 1,4) and when shell growth resumed the fracture was sealed internally from a position just apicad of it (Fig. 1). Also visible in Fig. 1 is the fine keel associated with the wrinkle-layer.

Dimensions:

	D	U	WW	WH
Lectotype, Wedekind 1914, p. 34.	60	27.7	17.7	20
HU P82.3	37.2	17.2	11.9	12.4
	29.8	13.8	ca 5.2	9.0
Mbg 3126	33.4	15.2	8.4	10.8
	29.2	13.6	7.3	10.3

Remarks: This species has been described simply because it is believed that most authors have treated this form as <u>Plat</u>. (<u>Plat</u>.) <u>annulata</u>. It is not possible, with only the photographs of type material available, to say which other species of <u>Platyclymenia</u> should be included in synonymy.

Comparisons: <u>Platyclymenia</u> (<u>Plat</u>.) <u>annulata</u> has more closely spaced, finer ribs on inner whorls, and tends to have a more square whorl section and a wider umbilicus. <u>Platyclymenia</u> (<u>Plat</u>.) <u>nodosa</u> has S-shaped growth-lines on the body chamber.

Horizon and distribution: There is no precise stratigraphic information for this species, believed to be restricted to the annulata Zone.

Platyclymenia (Platyclymenia) nodosa Münster 1839

Pl. 5.13, Figs. 9-11

1839 Clymenia binodosa var. nodosa nov. - Münster, p. 10.
1843 Clymenia binodosa var. nodosa Münster - Münster, p. 38, (copy of Münster 1839).
p. 1863 Clymenia annulata Münster - Gümbel, p. 131, pl. XVIII, figs. 11a-c only.

Type material: The specimen (BSP AS VII 600) which Gümbel figured (1863, pl. XVIII, figs. 11a-c) and claimed (1863, p. 132) was the "original" of Cl. binodosa var. nodosa Münster is proposed as the lectotype.

Diagnosis: Platyclymenia with compressed whorl section, converging flanks, rounded venter and strongly ribbed inner whorls, with smooth body chamber and radial weakly S-shaped growth-lines.

Description: Evolute, whorl section subcircular up to a diameter of 20mm, thereafter becoming quadrate (Pl. 5.13, Fig. 9). The first three whorls seem smooth, then the whorl between a diameter of ca 5 and 10mm has a sculpture consisting of 12 pairs of ribs. Only fragments of the shell of outer whorls are preserved; in the half whorl between a diameter of ca 15 and 20mm there are six single prominent radial, slightly concave ribs which diminish in strength, becoming blunt by a diameter of ca 32mm, and do not continue onto the umbilical wall.

Faint, rursiradiate plicate ribs are visible on the internal mould of the body chamber, though not on the shell itself, which shows only concavo-convex growth-lines.

Dimensions:

	D	U	WW	WH
BSP AS VII 600	58	23.4	12.8	21.4

Discussion: Münster's description (1839, p. 10) of the variety to which Gümbel attributed this specimen is short and lacks a figure: "Clymenia nodosa, a variety of Cl. binodosa, which has only a single row of tubercles on the outer side". Presumably Münster meant that his new variety had a series of ventro-lateral tubercles. It is clear that this description is difficult to apply to the specimen figured by Gümbel as Münster's "original". If Münster had had this large well preserved specimen to hand when he established the new variety nodosa it is likely that he would have illustrated it, or at least given a fuller description. Therefore, it is possible that this specimen does not come from the type series of Cl. nodosa. However, there are several unnumbered similar but less well preserved specimens in the Münster Collections at Munich and Berlin, all labelled as "nodosa Münster", thus it is certain that Münster interpreted the species in this way.

Frech (1902) drew attention to the similarity between this specimen and his new species Cl. intracostata from La Serre, Montagne Noire. Certainly from a comparison of the figures, the ornament and the whorl cross-section appear similar but Cl. intracostata should not be treated as a synonym until fresh material is collected from the type locality, the original material being untraced at present.

Horizon and distribution: The type locality is Schübelhammer, Oberfranken. The horizon of the lectotype is unknown, but is probably the annulata Zone.

Subgenus <u>Platyclymenia</u> (<u>Pleuroclymenia</u>) Schindewolf 1934

Type species: <u>Platyclymenia</u> <u>crassa</u> Schindewolf 1923a (= <u>Pleuro-clymenia</u> <u>crassissima</u> Schindewolf 1955 <u>nom</u>. <u>subst</u>. pro <u>Plat</u>. <u>crassa</u> which was preoccupied by <u>Plat</u>. <u>quenstedti</u> var. <u>crassa</u> Schindewolf 1923a), by original designation of Schindewolf 1934, p. 343.
Diagnosis: <u>Platyclymenia</u>, with depressed almost reniform whorl section and growth-lines which are radial over the flanks and form a broad sinus over the venter.

Description: Few species are well known, and a description is given below of the type species.

Available specific names:

<u>crassissima</u> Schindewolf 1955, p. 419, <u>nom</u>. <u>subst</u>. pro <u>Pleur</u>. <u>crassa</u> Schindewolf 1923a.

<u>americana</u> Raymond 1907, p. 118, textfig. 1. Three Forks Shale, Montana. Many strong ribs, growth-lines with a wide deep ventral sinus. Cross-section subrectangular with a depressed venter.

D	U	WW	WH
32	-	14	8
	-	12	9.5

<u>brevicosta</u> Wedekind 1908, p. 608, pl. XLIII, figs. 3,a (lecto-type proposed here) Beds 11-8 Enkeberg. Extremely depressed, reniform whorl section with numerous strong blunt radial ribs on inner whorls and a smooth body chamber.

h <u>crassa</u> Schindewolf 1923a, p. 458, textfig. 19c, (holotype Mbg 3154, proposed here) Kirschofen, Weilburg. Whorl section reniform with radial ribs.

D	U	WW	WH
37.5	15.0	15.5	12.4
34.5	15.5	11.6	11.6

<u>costata</u> Lange 1929, p. 63, pl. 2, fig. 14 (holotype) Beil. 30-35 ribs per whorl.

D	U	WW	WH
30	13	9	14

eurylobica Petersen 1975, p. 47, pl. 7, figs. 4-7, textfigs. 26,27B. This species (Textfig. 5.13, point 15, shows increasing depression of the whorl section and may be a Cyrtoclymenia).

D	U	WW	WH
14.5	5.4	7.7	5.5
10.8	4.4	5.0	4.3

humile Schindewolf 1934, p. 343, invalid substitution pro Var. brevicosta Wedekind 1908 which has a different spelling from Cl. brevicostata Münster 1842, and in any case belonged to a different genus and was not therefore a homonym. No type material of Cl. brevicostata Münster can be traced, the illustration of it is of a juvenile (Münster 1842, pl. XII, figs. 5,a,b) and it is therefore treated as a nomen dubium.

polypleura Raymond 1909, p. 5, pl. 7, figs. 4-6, textfig. 5. Ribs smaller and fewer than Pleur. americana with subcircular cross-section and small ventral sinus.

D	U	WW	WH
16	8.5	8	4

transita Kind 1944, p. 161, pl. 1, figs. 18,a.

Discussion: This is another case (cf. Gen. Nov. E, Gen. Nov. C) of Schindewolf establishing a new genus with a particular type species/specimen, but actually describing it with another. In this instance (1934) Pleur. americana was used to define the growth-lines of Pleuroclymenia. On americana these run straighter over the flanks, and have a deeper ventral sinus than on the type species. The whorl section is also considerably more depressed (see Textfig. 5.13).

Horizon and distribution: Species are known from the Rheinische Schiefergebirge (W. Germany), Thuringia (E. Germany), Canning Basin (W. Australia) and Montana and Ohio (USA). Few specimens are accurately dated, either by association with other species or otherwise. The Montana examples are from the Trident Member, Three Forks Formation, which has yielded a styriacus Zone conodont fauna (Sandberg and Poole 1977). Wedekind and Schindewolf believed that their specimens were from the delphinus Zone, and Lange suggested that his came from near the boundary of this and the overlying annulata Zone.

Platyclymenia (Pleuroclymenia) crassissima Schindewolf 1955

Pl. 5.16, Figs. 2,3,10, Textfigs. 5,12G,H

*v 1923a Platyclymenia crassa sp. nov. - Schindewolf, p. 458, textfig. 19c.

non 1923a Platyclymenia quenstedti var. crassa nov. - Schindewolf 1923a, p. 458, textfig. 19b.

Type material: Only the holotype Mbg 3154 (proposed designation herein) from Kirschhofen, Weilburg, is known.

Description: The holotype is evolute with depressed whorl section, which is reniform at a diameter of 36mm. The umbilical wall is short and curved slightly and the umbilico-lateral shoulder poorly defined. Textfig. 5.15 shows the ratio U/D to decrease and the ratio WW/WH to decrease greatly, with increasing diameter. The curved flanks run without break into the broad flattened venter. Growth-lines are barely visible but the ribs (Textfig. 5.12G), which run parallel, are radial, slightly convex over the flanks (but the holotype is distorted and also shows concave growth-lines/ ribs). In early whorls the ribs have a symmetric cross-section, but on the body chamber are asymmetric with the steeper face orad. Ribs are present at all visible diameters, but diminish in strength on the body chamber. The venter is smooth but the internal mould shows deep constrictions (Pl. 5.16, Fig. 1). The suture is illustrated in Textfig. 5.12G. It has a low ventral saddle.

Dimensions:

	D	U	WW	WH
Holotype, Mbg 3154	41			
Pl.5.16,Figs.1,2	35.7	15.0	15.5	12.4
figured by Schinde-	34.5	15.5	11.6	11.6
wolf 1923a, textfig.		10.9	12.3	8.3
19c.				

Discussion: Duplication of the specific name *crassa* in the original account (Schindewolf 1923a) of this species required that a substitute name be proposed. Matern (1931) proposed *crassoides*, but for the senior homonym, so this substitution was invalid. The situation was rectified by Schindewolf (1955), who proposed *crassissima*.

Horizon and distribution: Only the holotype is known and its age is uncertain, but is probably from either the *delphinus* or *annulata* Zones.

Subgenus *Platyclymenia* (*Trigonoclymenia*) Schindewolf 1934

Type species: *Clymenia spinosa* Münster 1842, by original designation of Schindewolf 1934, p. 343.
Diagnosis: Member of the *Platyclymenia* with parabolic ornament.

Description: Morphology resembles *Platyclymenia* with the exception of the ribbing. During shell growth there were periodic halts when an aperture was formed by resorption of shell on the outer flanks and the venter to give tear-shaped or concave indentations of the shell margin, cross-cutting pre-existing growth-lines. The way in which the apertural margin cuts across growth-lines is best seen in Pl. 5.17, Fig. 5. These features are the parabolic nodes of the diagnosis. Infilling of these sinuses resulted in the triangular structures (see Pl. 5.17, Fig. 4) which are alluded to in the generic name. Strong nodes are not always formed. In some cases a rib is formed by the approximation of several growth-lines which are only slightly transverse to the normal growth-lines. Between these two types there is a spectrum of variants with progressively deepening nodes such as are illustrated in Pl. 5.17, Figs. 1 and 8. Spiral ornament is a common feature.

Available species names includes:

spinosa	Münster 1842, p. 122, pl. XI, figs. 15a,b, Schübelhammer, Oberfranken.
biptycha	Lange 1929, p. 109, pl. 3, figs. 29,a, (holotype), 30, Beil, Sauerland.
barrandei	Wedekind 1914, pl. 3, figs. 13a-b, 14, pl. 7, fig. 4, Beil, (pl. 3) and Hövel (pl. 7), Sauerland.
crassicosta	Wedekind 1908, p. 616, pl. XLIII, figs. 1,a, Enkeberg, Sauerland.
curvicosta	Wedekind 1914, pl. 3, figs. 12a,b, pl. 7, fig. 3, Beil, Sauerland.
dorsocava	Schindewolf, 1923a, p. 455, pl. XVIII, fig. 1, textfig. 18, Kirch-Gattendorf, Oberfranken.
epicypha	Lange 1929, p. 110, Beil, Sauerland.
protacta	Wedekind 1908, p. 616, pl. XLIII, fig. 2, Enkeberg, Sauerland.

Discussion: The development of parabolic nodes was, presumably, to accommodate some protruding soft part, such as the eyes, when the body was withdrawn into the shell. Similar features can also be seen in Gonioclymenia (Kalloclymenia). Several species are distinguished principally by the shape of their parabolic nodes. However, since there is often considerable variation in nodal shape within one specimen this characteristic is of little diagnostic value. Most names will become synonyms of Plat. (Trig.) spinosa.

Horizon and distribution: Species are known from the Platyclymenia Stufe of the Sauerland, Oberfranken (W. Germany), Thuringia (E. Germany), Carnic Alps (Austria-Italy) and Algeria.

Platyclymenia (Trigonoclymenia) spinosa (Münster 1842)

Pl. 5.17, Figs. 2-8, Pl. 5.15

v*	1842	Clymenia spinosa sp. nov. - Münster p. 122, pl. XI, figs. 15a,b.
vp	1863	Clymenia spinosa Münster - Gümbel, p. 132, pl. XVI, figs. 1a-d, non fig. 2.
non	1929	Platyclymenia spinosa Münster - Lange, p. 115, pl. 3, figs. 32,a, 33.
	1934	Platyclymenia (Trigonoclymenia) spinosa Münster - Schindewolf, p. 341, textfig. 9.
?	1956	Platyclymenia (Trigonoclymenia) spinosa (Münster) - Müller, p. 75.
	1960	Platyclymenia (Trigonoclymenia) spinosa (Münster) - Petter, p. 32, pl. V, figs. 10,a,b, 22,a,b,

Type material: Gümbel (1863) recorded three specimens from Münster's collection in the BSP Munich. These are probably AS VII 521, 522 and 598. The largest of these, AS VII 598, is proposed as the lectotype and was figured by Münster (1842, pl. XI, figs. 15a,b).

Münster also mentioned specimens with shell; these are considered to be AS VII 521 and 522, which therefore are syntypes.

Diagnosis: Trigonoclymenia with quadrate whorl section and tear-shaped parabolic nodes on the ventrad part of the flanks.

Description: Four specimens were examined; the three syntypes and another specimen (KW 2064) from Schübelhammer in the collection of Dr. K. Wunderlich. All are figured in Pl. 5.17. Coiling is evolute with a rounded whorl section in the inner whorls, becoming compressed and quadrate with slightly convex converging flanks curving over into a flattened venter after a diameter of 40mm.

The ornament consists of ribs and parabolic nodes, which appear at a whorl height of ca 4mm (AS VII 522). The growth-lines are normally concave and radial (Fig. 5) with a deep sinus over the flat venter. When the parabolic node is formed shell is resorbed and a raised rim formed marginal to the tear-shaped node (Figs. 5,7) which has a different shape internally from externally (Fig. 7) being directed towards the venter, rather than towards the apex. At the same time as the node is being formed growth accelerates at the venter and the ventral sinus is infilled to form triangular structures (Figs. 4,6). Only a shallow ventral sinus is present during the period of cessation of growth. Nodes are present up to a diameter of at least 32mm, and there is a spiral ornament (Fig. 2, but better seen on Plat. (Trig.) barrandei, Fig. 1) and very shallow ribs on the venter (Fig. 3). At greater diameters the ribs diminish in strength, and are radial rather than rursiradiate (Fig. 2) and the whorl cross-section becomes more compressed (Fig. 8).

Dimensions:

	D	U	WW	WH
Lectotype, BSP AS VII 598	44	21.4	9.2	14.5
KW 2064	52	24.7	13	17

Discussion: The specimen figured by Gümbel (BSP BT, 1863, pl. XXI, fig. 2a) is excluded because it is a Gon. (Kalloclymenia). Lange and Müller were incorrect in eliminating from synonymy Gümbel's figures (1863, pl. XVI, figs. 1a-d), since three of these (1a-c) are based on the same specimen that Münster figured, which they did include in synonymy. The specimens in Lange's figures (1929, pl. 3, figs. 32,a, 33) seem to be closer to Plat. (Trigonoclymenia) *barrandei* (Wedekind 1914) in which the parabolic nodes are less deep, and the ribs sickle-shaped.

Comparisons: Wedekind (1914), Schindewolf (1923a) and Lange (1929) between them recognised at least another seven species of *Trigonoclymenia*. Mostly these were distinguished by whorl cross-sectional shape, or rib/node shape. All except *Trig. dorsocava* were described from Beil; this has a grooved venter and probably represents a distinct species. The others with ribs varying from simple to concave (*crassicosta*) and developing tear-shaped nodes progressively in the morphological series *protacta*-*barrandei*-*curvicosta*-*spinosa*. This, however, may simply represent variation within one species. I have insufficient material to determine this. A specimen from Hauern, figured in Pl. 5.17, Fig. 1, and closest to *Plat.* (*Trig.*) *barrandei* is included for comparison.

Horizon and distribution: The species has the same distribution as the genus, and probably comes from the *annulata* Zone.

Subgenus *Platyclymenia* (*Spinoclymenia*) Bogoslovskiy 1962

Type species: *Spinoclymenia aculeata* Bogoslovskiy by original designation of Bogoslovskiy 1962, p. 166.
Diagnosis: Similar to Platyclymenia but with paired radially directed spines, the bases of which lie on the ventro-lateral shoulder.

Description: The morphology of the only known species of this genus is similar to *Platyclymenia*, with the exception of the ventral spines. These are hollow, conical, are connected to the body and extend up to two-thirds of the whorl height radially away from the venter.

Remarks: This subgenus is included to complete the description of Platyclymenia. Spines such as these are known from no other Devonian ammonoids. The flares or spines formed on Teicherticeras, Acanthoclymenia, Pseudoclymenia, Gen. Nov. F and Kosmoclymenia all differ in not being connected to the body chamber, but are merely peripheral extensions of it, nor are they completely closed to form a hollow chamber. These spines may therefore have performed a different function.

Horizon and distribution: Species are known only from the Clymenia Stufe of the southern Urals (USSR).

Genus Stenoclymenia Lange 1929

Type species: Stenoclymenia stenomphala Lange 1929, by original designation of Lange 1929, p. 69.
Diagnosis: Member of the Platyclymeniinae with compressed whorl section, flanks converging to a flattened venter, plicate ribs and concave prorsiradiate growth-lines with a ventral sinus. Suture consists of a dorsal lobe, a broad lateral lobe and a flat dorsal saddle or shallow lobe.

Available species names include:

* stenomphala — Lange 1929, p. 70, pl. 2, fig. 15, holotype, from Enkeberg. Thinnly discoidal with a wide umbilicus.

D	U	WW	WH
36	15	7.2	12.5

prorsostriata — Schindewolf 1923a, p. 453, pl. XVII, fig. 9 (lectotype, Mbg 3127, proposed herein), Bed 11, Kirch-Gattendorf. Extremely compressed whorl section (Pl. 5.16, Fig. 4).

D	U	WW	WH
31	14	11	3.5

sandbergeri	Wedekind 1908, p. 620, pl. XLIV, figs. 9,a,10 (lectotype designated by Matern 1931, p. 101) Enkeberg. Ribbed, markedly quadrate cross-section.				
		D	U	WW	WH
		37.3	19.6	6	10.8
schindewolfi	Lange 1929, p. 71, pl. 2, fig. 16, holotype, Beil. Narrow umbilicus.				
		D	U	WW	WH
		41	13	21.4	11
? elegans	Kind 1944, p. 144, pl. 1, figs. 1,a, textfig. 1.				
valida	Phillips 1841, p. 126, pl. 54, fig. 245 (holotype GSM 7176) Landlake Qy., Launceston. Compressed flanks with numerous ribs, concave, prorsiradiate, at larger diameters these become superimposed onto shallow wide ribs, and bifurcate at the mid-flank, (Pl. 5.16, Figs. 7,8).				

Discussion: <u>Stenoclymenia</u> was established by Lange for species similar to <u>Platyclymenia</u> but with a compressed whorl section with flanks converging to a flattened venter and a suture distinguished by a shallow ventral lobe. Lange included this genus within the Gonioclymeniaceae, implying that the dorsal lobe was primary. Schindewolf (1934, 1937a) considered that this lobe was only secondary and a result of the flattening of the venter. Further examples of platyclymeniids with ventral lobes are <u>Plat</u>. (<u>Plat</u>.) <u>prorsostriata</u> and <u>Plat</u>. (<u>Trig</u>.) <u>dorsocava</u>. Recently Bogoslovskiy (1979b) has described as new genera other species which have flattened venters, compressed whorl sections and ventral lobes. These include <u>Kazakhoclymenia</u>, distinguished from <u>Cymaclymenia</u> and <u>Carinoclymenia</u> distinguished from <u>Rectoclymenia</u>.

The sutural ontogeny of <u>Stenoclymenia</u> is still unknown, but it is reasonable to assume, given the flattening of the ventral lobe in platyclymenias with a compressed whorl section and flattened venter, and the similar development of a secondary ventral lobe in other clymeniids, that the ventral lobe in Stenoclymenia is secondary. Therefore it is classified with the Platyclymeniinae, with which it has greater morphological similarity.

Horizon and distribution: The type species was dated as from the delphinus Zone, and Lange (1929) recorded another species from the annulata Zone. Bogoslovskiy (1979b) has extended the range up into the hoevelensis Zone. The genus is known from the Rheinische Schiefergebirge, Oberfranken (W. Germany), and presumably from the southern Urals (hence Bogoslovskiy's data).

Subfamily Nov. α

Textfig. 5.16

Proposed name: Piriclymeniinae.
Type genus: Piriclymenia Schindewolf 1937a.
Diagnosis: Platyclymeniidae with an arched ventral saddle, and adventive, lateral and dorsal lobes.

Description: Besides the characteristic suture members of this subfamily have a small shell with ventro -lateral grooves, growth-lines which are concavo-convex, or biconvex, and frequently have strong ribbing on the flanks.

Included genera:

Sulcoclymenia	Schindewolf 1972
Piriclymenia	Schindewolf 1937a
Ornatoclymenia	Bogoslovskiy 1979b

Remarks: Schindewolf (1972) argued that Sulcoclymenia and Piriclymenia were derived from Platyclymenia by the addition of an adventive lobe. He included these genera within the large family

Clymeniidae. Korn (1981a) suggested that <u>Ornatoclymenia</u> too was derived from <u>Sulcoclymenia</u>. Bogoslovskiy (1979b, 1981) included this group of genera within the Cyrtoclymeniidae. Full details of the classification adopted here are given in Chapter 4 but it suffices to say that here they are placed within a subfamily in the Platyclymeniidae, which recognises their close affinities with each other, and their direct origins in <u>Platyclymenia</u>, not <u>Protoxyclymenia</u>.

Horizon and distribution: Members of the subfamily are known from Rheinische Schiefergebirge, Oberfranken, s. Urals, Carnic Alps and N. Africa.

Genus <u>Sulcoclymenia</u> Schindewolf 1972

p 1923a <u>Cyrtoclymenia</u> Hyatt - Schindewolf, p. 427 (footnote).
p 1959 <u>Platyclymenia</u> Hyatt - Petter, p. 31.
1972 <u>Sulcoclymenia</u> gen. nov. - Schindewolf, p. 29.

Type species: <u>Cyrtoclymenia</u> <u>sulcata</u> Schindewolf 1923a, by original designation of Schindewolf 1972.
Diagnosis: Genus of Subfamily Nov. α with a shell which has weak ventro-lateral grooves, lacks strong ribs, and has an external suture consisting of shallow umbilical lobe, a shallow ventral lobe, and a ventral saddle.

Description: Only the type species has been named, and this is described below. It has concavo-convex growth-lines; other specimens (see below) differ only in being weakly ribbed, or having growth-lines which, as they run over the flank, are straight or biconvex.

Comparisons: This genus has a suture similar to <u>Piriclymenia</u>, but a simpler ornament, lacking ribs.

Remarks: This genus was established by Schindewolf (1972) to accommodate two specimens, named sulcata, which he had collected from Oberfranken years earlier (1923a), and specimens illustrated by Petter (1960) from the Sahara, to which she had given the same specific name. The genus was diagnosed by its suture, but the illustration which Schindewolf (1972) gave was not derived from the type material of the type species, but rather from the illustrations of the Sahara material. There can be no certain way of showing that sulcata Schindewolf = sulcata Petter, but in the absence of evidence to the contrary this suggestion is accepted here, but doubt must remain until material showing the suture has been obtained from Oberfranken (see Textfig. 5.12A).

Horizon and distribution: Known from the ?delphinus Zone of Oberfranken and North Africa.

Sulcoclymenia sulcata (Schindewolf 1923a)

Pl. 5.19, Figs. 10,11,14,15, Textfig. 5.12A

pv* 1923a Cyrtoclymenia sulcata sp. nov. - Schindewolf, p. 427, pl. XVI, fig. 10, (non fig. 11 = Sulcoclymenia aff. sulcata).

1960 Cyrtoclymenia sulcata Schindewolf - Petter, p. 31, pl. II, figs. 14, pl. III, figs. 3,a,5,b,6,a,9,a.

1972 Sulcoclymenia sulcata Schindewolf - Schindewolf, p. 29, textfig. 2, (copy of the suture from Petter's illustration).

Type material: Schindewolf (1923a) based his description on two specimens (Mbg 3129a,b), one of which (a), illustrated in Pl. 5.19, Figs. 10,11, is proposed as the lectotype. It was collected by

Schindewolf from Bed 10 at Kirch-Gattendorf.
Diagnosis: <u>Sulcoclymenia</u> with lirate concavo-convex growth-lines.

Description: The lectotype, although poorly preserved, is selected because it shows the part of the suture. Coiling is subevolute (U/D = 0.31). The whorl section is compressed; ventro-lateral grooves are present by a diameter of ca 12mm. Growth-lines (Textfig. 5.12A) are prorsiradiate, concavo-convex, with a broad sinus over the flank, and a narrow, prominent dorso-lateral salient which has its apex ventrad of the ventro-lateral grooves. Growth-line frequency is ca 5 per millimetre, at a diameter of ca 15mm. The poorly preserved suture (Textfig. 5.12A) is visible as an indistinct boundary between the sparry calcite infill of the last chamber, and the micrite infill of the body chamber.

A specimen (HU P82.1, Pl. 5.19, Figs. 14,15) from Geuser, and another from Wäschholz (KW 2065, Pl. 5.19, Fig. 19), both collected from loose blocks, are included within this species. The former is small but well preserved, and shows characteristic growth-lines numbering 7 per millimetre at a diameter of 12mm, and ventro-lateral grooves by a diameter of ca 7mm. The venter is weakly arched, and the growth-lines running across, although diminished in strength, form a deep U-shaped sinus. The suture was not observed. The specimen from Wäschholz is much larger (D = 25) and has the same whorl cross-section and growth-line frequency and course. At diameters greater than 20mm weak, concave ribs are formed over the flanks, over which the growth-lines are relatively bunched.

Dimensions:

	D	U	WW	WH
Lectotype,Mbg 3129a	17.5	5.4	4.0	6.3
HU P82.1	13.4	5.5	ca 3	4.2
KW 2065	26	11.2	-	ca 8.7

	D	U	WW	WH
Mbg 3129b	12.5	5.8	-	3.2
HU P82.2	14.7	6.2	3.1	4.3

Comparisons: Two specimens with a different ornament have been observed, but are not given specific distinction. One, Mbg 3129b, is a second specimen collected from Kirch-Gattendorf by Schindewolf. It (Pl. 5.19, Fig. 16) differs from the lectotype in being more evolute (U/D = 0.23), and having growth-lines which, over the flank, are slightly convex, rather than concave. The specimen from Wäschholz (HU P82.2, Pl. 5.19, Fig. 18) has truly biconvex growth-lines, which are bunched into groups of 5-7, alternately widely and closely spaced.

Remarks: The lectotype, although not the specimen figured by Schindewolf, is selected because it shows the suture. Growth-lines are not well preserved on Petter's material from the Sahara, but the enlarged figure (pl. III, fig. 3,a) and description show a concave course over the flank.

Horizon and distribution: Preparation of conodonts from the matrix of Mbg 3129b produced "no biostratigraphically useful forms" (Prof. W. Ziegler). The lectotype was collected from Bed 10 at Kirch-Gattendorf, accompanied by a fauna comprising Rectoclymenia and Genuclymenia, which suggests a delphinus Zone age.

Genus Piriclymenia Schindewolf 1937a

Type species: Platyclymenia piriformis Schmidt 1924, by original designation of Schindewolf 1937a, p. 31.
Diagnosis: Genus of the Subfamily Nov. α with a strongly ribbed pear-shaped body chamber, and a suture consisting of large and

strongly prorsiradiate ventral saddle, adventive and lateral lobes and a dorsal lobe (Textfig. 4.13E).

Description: Only the type species has been established, and this is described below.

Comparisons: Ornatoclymenia Bogoslovskiy 1979b has an homeomorphic shell shape, but is distinguished by its suture; its lateral lobe is similar to that of Cymaclymenia. Sulcoclymenia Schindewolf 1972, with similar shell form and suture has a less strongly pear-shaped whorl cross-section, lacks strong ribbing, and has a ventral saddle which is far less prominent.

Discussion: See Sulcoclymenia.

Horizon and distribution: This genus is known only from the Sauerland of the Rheinische Schiefergebirge, where Schindewolf (1937a) reported numerous examples from the Clymenia Stufe. Korn has recently used Piri. piriformis as an index for the fourth, uppermost zone of the Clymenia Stufe.

Piriclymenia piriformis (H. Schmidt 1924)

Pl. 5.19, Figs. 4,8,9, Textfig. 4.13E

	1921	"Clymenia" sp. aff. kayseri Drevermann - Schmidt, p. 284.
v*	1924	Platyclymenia piriformis sp. nov. - Schmidt, p. 125, pl. 6, figs. 18,19.
v	1937a	Piriclymenia piriformis Schmidt - Schindewolf, p. 37, fig. 4.
	1972	Piriclymenia piriformis Schmidt - Schindewolf, p. 28, fig. 2c.
	1979	Piriclymenia piriformis Schmidt - Korn, in Clausen, Korn and Uffehorde, p. 56, pl. I, figs. 1,2.

1981a <u>Piriclymenia</u> <u>piriformis</u> Schmidt - Korn, p. 174, figs. 1a-c, 2a,b, 3a-d, 4c.

Type material: Only one specimen from the type series, comprising at least five specimens (Schmidt 1924, p. 125), has been located by me. This, an unnumbered specimen in the MfN, figured by Schmidt (1924, pl. 6, figs. 18,a) is proposed as the lectotype.
Type locality: Schmidt (1924) gave Ainghausen (sic) for the origin of the lectotype. This is currently Enkhausen (Balve). However, the label associated with the lectotype reads "Lotz Collection, Hömberg, north side".

Description: The lectotype (Pl. 5.19, Figs. 8,9) is poorly preserved with little shell still adhering. Coiling is evolute, umbilical width amounting to 40-45% of the diameter, with a compressed pear-shaped whorl section and a narrow flattened venter, delimited by ventro-lateral grooves, which are more clearly expressed on the internal mould, than on the shell surface. Widely spaced radial ribs are present on the flanks and over the ventro-lateral shoulder; these swing forwards and become less marked on the body chamber. The complete growth-line course is not preserved but over the venter of the phragmocone impressions of strong lirae are present on the internal mould. A half-whorl of body chamber is preserved; on the first part of this the ribs are more closely spaced and then disappear, leaving an almost smooth internal mould. The only suture discernible consists simply of a ventral saddle and a broad lateral lobe, although this is damaged.

One other smaller specimen (MfN) has been examined (Pl. 5.19, Fig. 4). According to its label this is from south south east of Dählsen, and was used by Schindewolf (1937a, fig. 4) to illustrate the suture of this species. However, this specimen shows no sign of preparation in the dorsal area, which is included in Schindewolf's figure. The ribs on this specimen are far weaker, and more closely spaced than on the lectotype, but they show the same variation on the body chamber. The nature of the external suture, with its two lobes on the flank can be seen in Fig. 4. The ventral saddle runs strongly forwards through the ventro-lateral furrow, and narrow venter.

Comparisons: Ornatoclymenia ornata has a very similar shell form, and is only surely distinguishable when the suture can be seen.

Discussion: Only three other examples of this species have been figured (Korn 1981a, figs. 3a-d) and these demonstrate the broad way in which this species is interpreted. The ribbing is different on each specimen, all of which are preserved as internal moulds. In fig. 3a there are strong, widely spaced ribs with 2 or 3 inner ribs between. These minor ribs disappear from the flanks at a diameter of ca 7mm and are present only over the venter. Fig. 3c has widely spaced ribs only, and there are no weak ribs or growth-lines. Over the course of one whorl the specimen illustrated in fig. 3d has an ornament consisting of strong lirate growth-lines, followed by six strong ribs, and then the ribbing becomes less strong and more closely spaced, and finally indistinguishable from the growth-lirae. There is also variation between the three specimens in the relative size of the lateral lobes and their position.

With so few specimens available for study and no indication of their relative stratigraphic position the significance of this variability in ornament cannot be evaluated.

Dimensions:

	D	U	WW	WH
Lt., Pl.5.19,Figs.8,9.	19.1	8.3	ca 3.8	5.9
Pl. 5.19, Fig. 4.	14.7	6.2	3.5	4.7

Horizon and distribution: Korn (1981a) has used this species as the index for the fourth and uppermost zone of the Clymenia Stufe; it may range upwards into the Wocklumeria Stufe, though the base of this is currently not well defined. The species is known only from the Rheinische Schiefergebirge.

Genus Ornatoclymenia Bogoslovskiy 1979b

Type species: Clymenia ornata Münster 1834, by original designation of Bogoslovskiy 1979b, p. 36.

Diagnosis: Genus of the Subfam. Nov. α, with pear-shaped subtriangular whorl section, narrow venter delimited by ventro-lateral grooves, strong ribbing and a Cymaclymenia-type lateral lobe.

Description: Only the type species is known, and this is described below.

Comparisons: See Piriclymenia.

Discussion: Schindewolf (1937a) recognised that the absence of a deep umbilical lobe differentiates this species from other species of Cymaclymenia, but nevertheless included it within Cymaclymenia. Subsequently Kullmann (1960) and House (1970) questionably placed ornata in Kosmoclymenia and Cymaclymenia respectively. The generic position of the type species was settled, in a way, when Bogoslovskiy (1979b) established a new genus to contain it. When it was a species of Cymaclymenia, ornata was placed within the family Cyrtoclymeniidae (e.g. Schindewolf 1923a); Bogoslovskiy (1979b), using a different classification scheme, placed it in the Cymaclymeniidae.

On the basis of a poorly preserved specimen from the Cantabrian Mountains Kullmann (1960) questionably assigned the type species to the genus Kosmoclymenia and hence in the family Clymeniidae. This opinion was strengthened by Korn, enlarging on the argument of Schindewolf (1972), who had said that Piriclymenia was derived from Sulcoclymenia, and by suggesting that Ornatoclymenia too was derived from Sulcoclymenia.

Horizon and distribution: Korn (1981a) used the type species as an index fossil for the third zone of the Clymenia Stufe. The genus is known from Sauerland, Oberfranken (W. Germany), Carnic Alps (Austria-Italy), s. Urals (USSR) and possibly from the Cantabrian Mountains (Spain).

Ornatoclymenia ornata (Münster 1834)

Pl. 5.19, Figs. 1-3,5-7,13,14, Pl. 5.20, Figs. 5-7

Textfigs. 5.12D-F

*	1834	Clymenia ornata sp. nov. - Münster, p. 77.
	1839	Clymenia ornata Münster - Münster, p. 122, pl. II, figs. 7a-c.
	1843	Clymenia ornata Münster - Münster, p. 127, pl. II, figs. 7a-c (copy of Münster 1839).
v	1863	Clymenia striata var. ornata Münster - Gümbel, p. 147, pl. XVIII, figs. 9a-e, 10a-c.
	1921	Cymaclymenia ornata Münster - Schmidt, p. 288.
	1923a	Cymaclymenia ornata Münster - Schindewolf, p. 442.
	1924	Cymaclymenia ornata Münster - Schmidt, p. 132, pl. 7, figs. 4,5.
(?)	1929	Cymaclymenia ornata Münster - Lange, p. 92.
	1937a	Cymaclymenia ornata Münster - Schindewolf, p. 32, fig. 5.
(?)	1959	Cymaclymenia ornata Münster - Lewowicki, p. 97.
?	1960	Kosmoclymenia ? cf. ornata (Münster) - Kullmann, p. 536.
v	1970	Cymaclymenia (?) ornata (Münster) - House, pl. 126, figs. 16,17 (holotype).
	1979b	Ornatoclymenia ornata (Münster) - Bogoslovskiy, p. 37, pl. III, figs. 6,7, fig. 2.

1979 Piriclymenia (?) ornata (Münster) - Korn, p. 58, pl. 1, fig. 3, textfig. 3, figs. 7a-c.

1981a Ornatoclymenia ornata (Münster) - Korn, p. 179, figs. 2c,d, 3e-h, 4d, 5a-f.

Type material: BSP AS VII 550 is proposed as the lectotype.

Remarks: Both of the specimens figured by Gümbel (1863, pl. XVIII, figs. 9a-e) are to be found in the BSP, Munich. The specimen represented by figs. 9a,b, which Gümbel (1863) claimed was Münster's original, was illustrated by House (1970, pl. 126, figs. 16,17) as the holotype of the species. Münster when he first described the species (1834, p. 77) failed to give a figure, or to state how many specimens he had. Subsequently he figured an example (1839, pl. II, figs. 7a-c) which is approximately the same size as the specimen represented in Gümbel's figs. 9a,b. This specimen, AS VII 550, is believed to be the specimen figured by Münster (1839), and is proposed as the lectotype, rather than the holotype, since it can never be shown that the type series consisted of just one specimen.

Diagnosis: Ornatoclymenia with umbilical width amounting to approximately 50% of the diameter, compressed pear-shaped whorl section, and ornament consisting in large specimens of lirate growth-lines with a concavo-convex course, becoming biconvex and bunched so as to form ribs.

Description: Four specimens from Schübelhammer collected by Münster (MfN, SM H10382 and BSP AS VII 550,551) were available for study, together with four specimens (MfN) collected by Schmidt from "Ziegelei (= brickyard) Müller, Üllendahl".

The lectotype, BSP AS VII 550 (Pl. 5.19, Figs. 5-7) is reasonably well preserved and shows most of the features of the mature shell. The umbilical width amounts to 40% of the diameter, at a diameter of 26.5mm, where the compressed whorl section is pear-shaped with clearly developed ventro-lateral grooves delimiting the high arched venter.

The lirate biconvex growth-lines (Textfig. 5.12F) are alternately widely and closely spaced on the flanks, the bunched growth-lines forming ribs, which are also visible on the internal mould. Over the venter growth-lines are equally spaced, and form a shallow sinus. The Cymaclymenia-type suture is illustrated in Textfig. 5.12F, but has been revealed by polishing and so may not represent the true form.

Two other Münster specimens allow more details of the species to be determined. The small specimen from Berlin (Pl. 5.19, Figs. 12,13) has a whorl section which is subcircular up to a diameter of 7mm. Thereafter the umbilical walls are more clearly defined, and the flanks are less strongly curved. After a diameter of 17mm the groove develops on the flatly rounded flanks. The growth-lines at all stages are prorsiradiate and weakly biconvex, with a broad mid-flank sinus. Ribbing is not visible externally, but only on the internal mould of the body chamber, commencing at a diameter of ca 12mm.

The whorl cross-section can be clearly seen on SM H10382 (Pl. 5.20, Figs. 5-7, Textfig. 5.12E). The ventro-lateral grooves are formed by the shell thinning in that region, and the internal mould has a simple subtriangular shape. This contrast can be detected on all three specimens, where there is a strong groove externally, but this is absent or weak on the internal mould. Growth-lines are biconvex (Textfig. 5.12D), groups of four alternately bunched and widely spaced on the flanks so as to form ribs. Growth-lines number three per millimetre on the venter at a diameter of 20mm, but become more crowded after this, doubling their frequency where the ribbing is lost on the last quarter whorl. The earliest sign of ribbing is developed by an umbilical width of 2.2mm, where there are umbilical tubercles. Ribs disappear at a diameter of 20mm.

All of the specimens from Elberfeld (Pl. 5.19, Fig. 1) are preserved flattened in shales, with no sign of the suture and so cannot certainly be assigned to this genus. BM C82398, also from Oberfranken, is recognised as belonging to this species.

Discussion: This species dates from 1834 and not 1839 as stated by all authors listed in the synonymy. The relationship of this species to Sulcoclymenia and Piriclymenia on the one hand, and Cymaclymenia on the other, has already been discussed. Suffice it to say that it is not absolutely certain with which *Orn. ornata* has closer affinities.

Dimensions:

	D	U	WW	WH
Lectotype, BSP AS VII 550	26.5 20.6	12.4 8.5	ca 5.5 6.4	ca 8 7.8
BSP AS VII 551 Pl.5.19, Figs.2,3.	23	-	7	10
SM H10382	22.2	10.2	ca 7.5	8.0

Horizon and distribution: *Orn. ornata* is known from the Clymenia Stufe of the Sauerland, Oberfranken, and the southern Urals. Korn (1981a) used the species as the index fossil for the third highest zone of the Clymenia Stufe.

Family Cyrtoclymeniidae Hyatt 1884

Type genus: Cyrtoclymenia Hyatt 1884

Diagnosis: Clymeniaceae with subinvolute to subevolute coiling, globose to thickly discoidal shell, biconvex growth-lines with prominent ventro-lateral salient, and simple suture comprising broad lateral lobe and dorsal lobe.

Description: Shells are usually smooth, weak ribs are developed near the umbilicus in some species. Septal necks are short.

Included genera:

Cyrtoclymenia	Hyatt 1884
Protactoclymenia	Wedekind 1908

Remarks: Protactoclymenia, established without a type species, has been revived to contain subevolute species, previously included in Varioclymenia or Cyrtoclymenia. Cyrtoclymenia, a long-ranging genus, includes a spectrum of forms and is divided here into morphological groups.

Comparisons: The Platyclymeniinae are all evolute and have concave growth-lines. The Carinoclymeniidae and Rectoclymeniidae have a more compressed, sometimes oxyconic shell-form, and again, different growth-lines.

Horizon and distribution: Protactoclymenia is known only from the delphinus and annulata Zones of the Rheinische Schiefergebirge (W. Germany). Cyrtoclymenia is known from the Rheinische Schiefergebirge, Oberfranken, Thuringia (Germany), Poland, England, Brittany, Carnic Alps (Austria-Italy), Cantabrian Mountains (Spain), Montagne Noire (France), North Africa, Novaya Zemlya, Urals, Kazakhstan (USSR), and Western Australia.

Genus Cyrtoclymenia Hyatt 1884

Textfig. 5.18

*	1884	Cyrtoclymenia gen. nov. - Hyatt, p. 313
p	1908	Varioclymenia gen. nov. - Wedekind, p. 605.
p		Protactoclymenia gen. nov. - Wedekind, p. 608.
p	1914	Protactoclymenia Wedekind - Wedekind, p. 20.
		Cyrtoclymenia Wedekind - Wedekind, p. 26.
p	1923a	Cyrtoclymenia Hyatt - Schindewolf, p. 421.
p	1924	Cyrtoclymenia Hyatt - Schmidt, p. 126.
p.		Lenticlymenia gen. nov. - Schmidt, p. 126.
	1929	Cyrtoclymenia Hyatt - Lange, p. 85.
	1931	Cyrtoclymenia Hyatt - Matern, p. 96.
p	1953	Cyrtoclymenia Hyatt-Nalivkina, p. 101.
	1957	Cyrtoclymenia Hyatt - Schindewolf, p. L45.
	1960	Cyrtoclymenia Hyatt - Petter, p. 39.
	1962	Cyrtoclymenia Hyatt - Bogoslovskiy, p. 407.
	1962	Cyrtoclymenia Hyatt - House, p. 279.

Type species: Planulites angustiseptatus Münster 1832, by original designation of Hyatt 1884.
Diagnosis: Subinvolute Cyrtoclymeniidae, with biconvex or concavo-convex growth-lines.

Description: This heterogeneous and long-ranging genus encompasses a variety of forms, which are split here into three morphological groups, named after species within them: involuta, angustiseptata and plicata.

involuta Group

The involuta Group contains species with a subinvolute compressed to subglobular shell form, and growth-lines with a prorsiradiate biconvex course, but the concave portion over the flank is extremely shallow. Two examples of Cyrt. involuta itself, from Beringhausen and Beil (Fig. 6), are illustrated (Pl.

5.34, Figs. 1,2,6, Textfigs. 5.17C-E) to show the shell form and ornament. Schmidt (1924) described the septal necks from this species as being short, extending for only one third of the distance between adjacent septa. Perna (1914) regarded _Cl_. _frechi_ Tokarenko as a synonym of _involuta_ (but considered them to represent sexual dimorphs). Wedekind described a stouter variety, _crassa_ (Pl. 5.34, Figs. 3-5) which has growth-lines which are almost straight with ribbing at the umbilical shoulder, and a shallow broad ventral salient.

Various authors have named species considered to belong within this group, which include:

crassa	Wedekind 1914, p. 21, pl. 1, figs. 8a,b,9.
frechi	Tokarenko 1903, p. 33, pl. III, fig. 6.
involuta	Wedekind 1908, p. 608, pl. XLIV, figs. 1,a.
krasnopolski	Perna 1914 (non Chernyshev 1887b), p. 19, pl. II, figs. 17a,b,18a-c.
lenticularis	Petter 1960, p. 44, pl. VII, figs. 15,a.
stenomphala	Petter 1960, p. 42, pl. VI, fig. 4, pl. VII, figs. 7,a,13,a.
uralica	Nalivkina 1953, p. 103, pl. IV, figs. 4a,b, = ? _krasnopolski_ Chernyshev 1887b, pl. 1, figs. 17-21.

These species are known from the _delphinus_ and _annulata_ Zones of Rheinische Schiefergebirge, Novaya Zemlya, southern Urals and North Africa. Wedekind used _Cyrt_. _involuta_ in conjunction with _Prol_. _delphinus_ as indicators of his IIIβ zone.

plicata Group

The second group, characterised by strong concave ribbing, is exemplified by _Cyrt_. _plicata_. Species known from the _Clymenia_ and _Wocklumeria_ Stufen of Rheinische Schiefergebirge, Oberfranken Cornwall and North Africa include:

	cincta	Münster 1839, p. 9, pl. XVI, figs. 5a-c.
h	crassa	Petter 1960, p. 43, pl. VI, figs. 13,16,a, pl. VII, figs. 6,a, textfig. 4H.
?	fasciata	Phillips 1841, p. 125, pl. LIII, figs. 242.
	plicata	Münster 1832, p. 32, pl. VI, fig. 7.
	plurisepta	Phillips 1841, p. 126, pl. LIV, fig. 244.
	subnodosa	Münster 1832, p. 32, pl. VI, fig. 7.

angustiseptata Group

The last group contains angustiseptata, the poorly known type species of Cyrtoclymenia. It comprises compressed, smooth shelled species, with biconvex growth-lines from the Clymenia and Wocklumeria Stufen of the Rheinische Schiefergebirge, Thuringia, Oberfranken, Silesia, Carnic Alps, Montagne Noire, Algeria, southern Urals, USA, and includes:

angustiseptata	Münster 1832, p. 7, pl. I, figs. 3a-c.
inflata	Münster 1832, p. 7, pl. I, figs. 5a,b.
lata	Münster 1832, p. 7.
lateseptata	Schindewolf 1924, p. 106.
strigata	House 1962, p. 279, pl. 47, figs. 8,9, pl. 48, figs. 1-5.
tetragona	Schmidt 1924, p. 127, pl. 6, figs. 22,23.
ventriosa	Petter 1960, p. 41, pl. VI, figs. 5,a,12,a, 15,a, pl. VII, figs. 18,a, textfig. 4E

Cyrtoclymenia tetragona, which differs from other species in the group, is included here for expediency. It has a distinctive shell form with flat converging flanks and a flatly arched venter. The growth-lines, poorly visible on the lectotype (MfN, Pl. 5.35, Fig. 1) are biconvex with an extremely prominent but narrow ventro-lateral salient. Examples are known from the Wocklumeria Stufe of the Sauerland and Cornwall.

A number of species, all with simple concave lateral lobes, are not assigned to a particular genus, largely because the material on which the names were based is poorly preserved or inaccessible. These are listed below, for completeness' sake. Most were introduced by Sobolev (1912, 1914a, 1914b). The first two papers were in Russian and the last one is concerned with phylogenetic concepts, and newly introduced species were not described individually. The illustrations for these publications, to which I have had access, show the fauna to be well preserved as haematitic (?) internal moulds. Growth-lines are, for the most part, not visible in the photographs, so there is little benefit in speculating to which particular genus these species belong.

<u>campanulata</u>	Richter 1848, p. 29, figs. 66-72.
<u>compressa</u>	Münster 1832, p. 7, pl. I, figs. 4a-c.
<u>curvidorsata</u>	Sobolev 1914a, p. 9, pl. IV, figs. 5-7, pl. VIII, figs. 26,7.
<u>djartassensis</u>	Nalivkina 1953, p. 28.
<u>flexilobata</u>	Sobolev 1914a, p. 64, pl. IX, fig. 33, fig. 118.
<u>genulobata</u>	Sobolev 1914a, p. 66, pl. IX, figs. 37a,b, figs. 12,13.
<u>gracilis</u>	Schmidt 1924, p. 126, pl. 6, figs. 20,a, 21.
<u>gracilis</u>	Nalivkina 1953, p. 111, pl. 4, fig. 14.
<u>kajraktensis</u>	Kolotukhina 1938, p. 678, pl. 2, figs. 5,a, 6,7, figs. 6,7,8.
<u>lagowiense</u>	Sobolev 1912, p. 10, pl. 3, fig. 5.
<u>planiloba</u>	Sobolev 1914b, p. 354, pl. 8, figs. 5a,b, fig. 3.
<u>rotundata</u>	Sobolev 1914b, p. 361, pl. 9, figs. 28a,b.
<u>subacuta</u>	Sobolev 1914a, p. 30, pl. 9, figs. 12a,b, 15a,b, fig. 27.
<u>subcostata</u>	Sobolev 1914b, p. 362, pl. 9, figs. 25a,b,26a,b.
<u>tenuis</u>	Sobolev 1912, p. 9, pl. III, figs. 7a,b.
<u>undosa</u>	Sobolev 1914b, p. 360, pl. 9, figs. 7,8.

Little is known of the species listed above, although the following observations may be added:

campanulata Richter: based on two distorted internal moulds showing a Cyrtoclymenia suture - a nomen dubium.
compressa Münster: based on a weathered internal mould - a nomen dubium (see also Cymaclymenia below).
gracilis Schmidt: based on a weathered internal mould (MfN) - a nomen dubium.
gracilis Nalivkina: if a Cyrtoclymenia, then this is a junior secondary homonym of gracilis Schmidt.
kjraktensis Kolotukhina: this, together with varicata and callimorpha, all described in the same article, are probably referrable to Plat. (Pleuroclymenia) callimorpha (Lange).

Cyrtoclymenia angustiseptata (Münster 1832)

Pl. 5.34, Figs. 11-13,16,17, Textfig. 5.17F

*v	1832	Planulites angustiseptatus sp. nov. - Münster, p. 7, pl. I, figs. 3a-c.
(?)	1832	Goniatites latus sp. nov. - Münster, p. 17.
	1834b	Clymenia angustiseptata Münster - Münster, p. 69, pl. I, figs. 3a-c (refiguring of the lectotype).
(?)	1839	Clymenia lata Münster - Münster, p. 7.
	1843	Clymenia angustiseptata Münster - Münster, p. 4, pl. 1a, figs. 3a-c (refiguring of the lectotype).
	1863	Clymenia angustiseptata Münster - Gümbel, p. 110, pl. XV, figs. 1a-c.
	1923a	Cyrtoclymenia angustiseptata Münster - Schindewolf, p. 428.
	1924	Cyrtoclymenia angustiseptata Münster - Schmidt, p. 127.
?	1929	Cyrtoclymenia angustiseptata Münster - Lange, p. 87.
non	1960	Cyrtoclymenia angustiseptata (Münster) - Petter, p. 40, pl. VI, figs. 9,a,17,a, pl. VIII, fig. 7, fig. 4I.

Type material: A lectotype, BSP AS VII 585, is proposed here. This was collected by Münster from Schübelhammer, Oberfranken.
Remarks: The composition of the type series is unknown, therefore,

this specimen is proposed as the lectotype.

Diagnosis: Subevolute Cyrtoclymenia (U/D=0.25) with slightly compressed whorl section (WW/WH 0.9-1.0). Growth-lines are prorsiradiate, biconvex with a more prominent ventro-lateral salient, and a deep ventral sinus. Weak ribs are present around the umbilicus.

Description: Only the lectotype has been seen. This, BSP AS VII 585, is illustrated in Pl. 5.34, Figs. 11-13, and is poorly preserved. Therefore little information can be added to the diagnosis.

The body chamber amounts to three-quarters of a whorl in length, and the last four septa are approximated, suggesting that this is a mature specimen. The whorl section has flanks which are flatly converging towards a rounded venter. The suture is illustrated in Textfig. 5.17F.

Dimensions:

	D	U	WW	WH
Lectotype, BSP AS VII 585	56.4	14.3	17,6	23.8
	46	12.7	18	19.5
BSP AS VII 599	56	14	21	25.5

Discussion: The lectotype is poorly preserved, and so the characters of the species, and hence the genus Cyrtoclymenia, have not been fully elucidated. Gümbel (1863) reported only one specimen in the Münster Collection at Munich, and no others have been traced. Schindewolf (1923a) seems to have found no well preserved specimens from Kirch-Gattendorf.

Various authors have reported this species (see the list in Foord and Crick 1897, p. 18), but few examples have been illustrated. The name has been used broadly in the sense of Cyrtoclymenia sp. Schmidt (1924, pl. 6, fig. 24) figured an unhelpful cross-section, and did not describe growth-lines. Lange (1929) described poorly preserved examples with "almost radial" growth-lines, in contrast to those on the lectotype.

In 1937 Schindewolf (1937a) reported Cyrt. angustiseptata from throughout the Wocklumeria Stufe, but did not describe it. Later (1952) he figured a whorl section of the lectotype. Petter (1960) described several specimens from the Platyclymenia and Clymenia Stufen of Algeria. The growth-line shape is not visible in her illustrations, but her account mentioned a ventro-lateral saddle, and a flank sinus of similar proportions, which is markedly different from the growth-lines of the lectotype. Growth-lines cannot be seen on the large undescribed specimen figured by Bogoslovskiy (1962, pl. XXXI, figs. 3a,b).

Münster described (1832, p. 17) G. latus, a species with a "flat rounded side lobe". Later (1839, p. 7), from observations on a newly found specimen, he recognised this to be a Clymenia, by its ventral saddle and siphuncular position. It was probably this highly weathered specimen, lacking all indication of growth-lines, which Gümbel illustrated (1863, pl. XV, figs. 3a-c). It (BSP AS VII 599) is shown here in Pl. 5.34, Figs. 16,17. This specimen is proposed as the lectotype. The whorl outline clearly resembles that of Cyrt. angustiseptata, but its preservation means that interpretation of this species is virtually impossible, and so it is declared a nomen dubium.

Schmidt (1924, pl. 6, figs. 25-8) illustrated specimens which he assigned to Cyrt. lata. One at least (fig. 26; Pl. 5.35, Figs. 6,7) has weak ribs around the umbilical shoulder and so cannot be compared with Cl. lata Münster. Nor, however, can it be compared with other ribbed species of Cyrtoclymenia (see Cyrt. plicata, below).

Comparisons: Most other species of Cyrtoclymenia have differently shaped growth-lines, and thus can be distinguished. Cyrt. ventriosa Petter (1960) has similar growth-lines, but a much thicker whorl section, like Cyrt. aff. angustiseptata described by Schindewolf (1952). Cyrt. strigata House (1962) has a sub-involute and more discoidal whorl section, with converging flanks, a strigate ornament, and its ventro- lateral growth-line salient is broader and less prominent.

Horizon and distribution: Of modern authors only Schindewolf is able to have interpreted the species correctly, since he alone had seen the lectotype. Therefore, accepting his opinion, Cyrt. angustiseptata is known from the Wocklumeria Stufe of Oberfranken, Thuringia, Dzikowiec, Montagne Noire and the Carnic Alps.

?Cyrtoclymenia inflata (Münster 1832)

Pl. 5.34, Figs. 18,19

v*	1832	Planulites inflatus sp. nov. - Münster, p. 7, pl. I, figs. 5a-b.
	1834b	Clymenia inflata Münster - Münster, p. 70, pl. I, figs. 5a-b (copy of Münster 1832).
	1843	Clymenia inflata Münster - Münster, p. 4, pl. Ia, figs. 5a-b (copy of Münster 1832).
v	1863	Clymenia inflata Münster - Gümbel, p. 120, pl. XV, fig. 5 (refiguring of the holotype).

Type material: BSP AS VII 536 from Schübelhammer, Oberfranken, is recognised as the holotype.

Remarks: Münster (1832) stated that he had only one specimen.

Diagnosis: Cyrtoclymenia with depressed whorl section umbilical width amounting to 30% of the diameter, and smooth shell.

Description: Only the holotype has been seen (Pl. 5.34, Figs.

18,19) and this is badly weathered so that no details of the ornament are preserved. The shell at a diameter of 100mm has an umbilical width of 30mm. Half a whorl prior to this the ratio WW/WH is 1.2. At a whorl height of 41mm the shell wall is 2.5mm thick at the mid-flank and 1.2mm thick at the venter. There is a convex constriction running across the flank of the internal mould, widest near to the umbilical shoulder and narrowing towards the venter. The suture, scratched out on the inner whorls, consists of a broad lateral lobe.

Dimensions:

	D	U	WW	WH
Holotype, BSP AS VII 536	98	30	37	31

Discussion: This species will remain poorly known unless better preserved material can be located. However, identification of the holotype means that future interpretation should not be ambiguous.

Horizon and distribution: An unknown level (?Clymenia Stufe) in Oberfranken.

Cyrtoclymenia plicata (Münster 1839)

Pl. 5.35, Figs. 15-18, Textfig. 5.17G

?	1832	Goniatites subnodosus sp. nov. - Münster, p. 32, pl. VI, fig. 7.
?	1834b	Goniatites subnodosus Münster - Münster, p. 95, pl. VI, fig. 5 (translation of Münster 1832)
	1839	Clymenia subnodosa Münster - Münster, p. 8.
v*	1839	Clymenia plicata sp. nov. - Münster, p. 8, pl. XVI, figs. 4a-c.

v 1839 Clymenia cincta sp. nov. - Münster, p. 9, pl. XVI, figs. 5a-c.

1843 ?Clymenia subnodosa Münster - Münster, p. 25, pl. VIa, fig. 7 (copy of Münster 1832).

1843 Clymenia plicata Münster - Münster, p. 36, pl. XVI, figs. 4a-c (copy of Münster's 1839 figure).

1843 Clymenia cincta Münster - Münster, p. 37, pl. XVI, figs. 5a-c (copy of Münster's 1839 figure).

vp 1863 Clymenia angustiseptata Münster - Gümbel, p. 120, pl. XV, figs. 2a-c (refiguring of the lectotype of Cl. plicata), figs. 4a-c (refiguring of the lectotype of Cl. cincta) ?figs. 6a-c,e (refiguring of the lectotype of Cl. subnodosa).

? 1914 Cyrtoclymenia cf. plicata Münster - Wedekind, p. 26, pl. V, figs. 2a-b.

p 1923a Cyrtoclymenia plicata Münster - Schindewolf, p. 430.

v 1924 Cyrtoclymenia plicata Münster - Schmidt, p. 128, pl. 6, figs. 29,a.

? 1960 Cyrtoclymenia crassa sp. nov. - Petter, p. 43, pl. VI, figs. 13,16,a, pl. VII, figs. 6,a, textfig. 4A.

Type material: BSP AS VII 584, collected by Münster from Schübelhammer, Oberfranken, is proposed as the lectotype.
Diagnosis: Cyrtoclymenia with blunt concave ribs on the flanks near to the umbilicus, numbering ca 14 per whorl.

Description: Cyrt. plicata will be described, and then be compared with other ribbed species of Cyrtoclymenia. Two specimens have been seen, the lectotype (Pl. 5.35, Figs. 17,18) and an unnumbered specimen in the Museum für Naturkunde, Berlin (Pl. 5.35, Figs. 15,16).

The lectotype is clearly recognisable as the specimen illustrated, almost without elaboration, by Münster (1839) and Gümbel (1863). It is an incomplete weathered internal mould with remains of ribs on the inner whorls. Early whorls are unknown. The whorl section is depressed at a radius of 35mm (WW/WH = 0.16). At a diameter of about 30mm the ribs are blunt, strongest near the umbilical shoulder, and concave. The simple external suture, consistimg of a shallow concave lateral lobe, and a ventral saddle, is illustrated in Textfig. 5.17G.

The better preserved example in the Münster Collection at Berlin clearly shows concave ribs with swellings near the umbilicus, numbering eight in the half whorl prior to a diameter of 40mm. Ribs are absent from the body chamber.

Dimensions:

	D	U	WW	WH	R
Lectotype, BSP AS VII 584.			25.5	22	35
MfN, Pl.5.35,Figs. 15,16.	53	17	21	21	
_Cl_. _cincta_, lectotype, BSP AS VII 583.	45 32.7	15 10.6	25 16.8	19.8 16.5	
_Cl_. _subnodosa_ lectotype, BSP Pl.5.35,Figs.4,5.	19.2	4.9	6.8	8	
_Cl_. _fasciata_, GSM 7172, lectotype.	35		18.1	ca15	
_Cl_. _plurisepta_, GSM 7174, lectotype.	26	6.8	10.5	12.5	

Discussion: Wedekind (1914) described two genera, _Protactoclymenia_ and _Cyrtoclymenia_, without defining how they were to be distinguished. Only one specimen was assigned to _Cyrtoclymenia_ and this, _Cyrt_. cf. _plicata_ (pl. 5, fig. 2), was poorly preserved and showed remains of neither ornament nor growth-lines. Thus its specific designation must be uncertain.

Schindewolf (1923a) adopted the same approach that is used here, and included all ribbed species of _Cyrtoclymenia_ as _Cyrt_. _plicata_. Schmidt (1924, pl. 6, figs. 29,a) figured an example (Pl. 5.35, Figs. 3,4) from Ense which had concave ribs, with swellings near to the umbilicus, which is recognised as belonging to this species.

In 1839 Münster also introduced two further ribbed species of Clymenia, cincta and subnodosa. The lectotype of Cl. cincta is recognised as BSP AS VII 583 (Pl. 5.35, Figs. 6-10), which is the specimen upon which the illustrations of Gümbel and Münster were based. It is subevolute with a ratio U/D of 0.32, an almost circular whorl section with a well defined, steep umbilical wall, and converging flanks which run into a broad rounded venter. The shell is not well preserved, and no growth-lines can be seen. There are, however, strong ribs, straight or slightly biconvex, continuing over the venter in a shallow sinus, prorsiradiate, numbering 40 in the whorl prior to a diameter of 45mm. One third of a whorl of body chamber is preserved, and there is a normal Cyrtoclymenia suture.

The proposed lectotype of Cl. subnodosa (BSP, Pl. 5.35, Figs. 4,5) is a small specimen with 20 concave ribs strongly developed on the dorsad portion of the flanks, but barely visible on the ventrad half. It has a normal Cyrtoclymenia suture. This specimen is much larger than that figured by Münster as G. subnodosus, which is lost, and so the species is considered as a nom. dubium.

The lectotypes of Cl. plicata, subnodosa and cincta are distinctive and different. One has widely spaced concave ribs, one closely spaced concave ribs, and the other closely spaced straight or weakly biconvex ribs. How closely they are related to one another cannot be determined because so few examples of ribbed Cyrtoclymenia are known.

Two ribbed specimens now recognised as Cyrtoclymenia were described by Phillips (1841) from Petherwin Cornwall: Cl. fasciata, lectotype GSM 7172, Pl. 5.35, Figs. 11,12, (p. 125, pl. XLIII, figs. 242a-d) and Cl. plurisepta, lectotype GSM 7174, Pl. 5.35, Figs. 13,14, (p. 126, pl. LIV, figs. 244a-c). These are both very poorly preserved, with little or no trace of shell remaining. Weak ribbing can be seen, especially near to the umbilicus, but nothing more. Association of these specimens with one of the German specific names (or vice versa) would be pointless (see Pl. 5.35); more material from Cornwall is required. Their whorl sections appear similar to Cyrt. plicata, as Selwood (1960) pointed out.

Petter (1960) established crassa, a new variety of Cyrtoclymenia enkebergensis Wedekind, for a number of depressed, ribbed specimens from the Platyclymenia Stufe of the Saoura Valley of Algeria. The ribs are concave and number ca 17 per whorl. Like the Münster species described here they are strongest near to the umbilical shoulder. The major morphological distinction between these specimens and Cl. subnodosa, which has a similar whorl outline, and ornament, is the umbilical width, which amounts to 30% of the diameter, between diameters of 12 and 36mm. The use of crassa as a subspecific name was illegal, since it was preoccupied by involuta var. crassa Wedekind (1914).

Horizon and distribution: Schindewolf (1923a) collected specimens he referred to Cyrt. plicata from the Wocklumeria Stufe of Kirch-Gattendorf, Oberfranken, and later (1937a) at Oberrödinghausen in the Hönnetal, he showed the species to range throughout the whole of the Wocklumeria Stufe. No other occurrence of strongly ribbed specimens of Cyrtoclymenia are dated, except for crassa Petter, which was stated to be from the Platyclymenia Stufe of Algeria.

Genus Protactoclymenia Wedekind 1908

*p 1908	Protactoclymenia gen. nov. - Wedekind, p. 605,8.	
p	Varioclymenia gen. nov. - Wedekind, p. 605.	
p 1914	Protactoclymenia (Protactoclymenia) Wedekind - Wedekind, p. 21.	
p	Varioclymenia Wedekind - Wedekind, p. 29.	
1923a	Cyrtoclymenia Hyatt - Schindewolf, p. 421.	
p 1924	Lenticlymenia nom. nov. - Schmidt, p. 126.	
p 1929	Cyrtoclymenia Hyatt - Lange, p. 85.	

Type species: Protactoclymenia pulcherrima Wedekind, proposed here.

Diagnosis: Cyrtoclymeniidae with discoidal subevolute shell form, and concavo-convex growth-lines.

Description: The shell form is discoidal and subevolute. The whorl section is compressed, quadrate, with a flatly rounded venter. Growth-lines are concavo-convex, often with a prominent ventro-lateral salient resulting in falcate growth-lines. Ribbing is common, especially near to the umbilicus of inner whorls. The suture consists of a dorsal lobe, a broad concave lateral lobe and a ventral saddle.

Species included here are:

*	pulcherrima	Wedekind 1908, p. 608, pl. XLIII, figs. 13,a
?	crassa	Wedekind 1914, p. 31, pl. V, figs. 3a,b.
	enkebergensis	Wedekind 1908, p. 606, fig. 1.
	euryomphala	Wedekind 1914, p. 31, pl. 1, figs. 12a-c.
	posterior	Lange 1929, p. 86, pl. 2, fig. 22.
	steinmanni	Wedekind 1908, p. 615, pl. XLIII, figs. 12,a.

Remarks: This generic name is used for this distinctive group because it has already been applied to some members, including the proposed type species. Its relationship to other genera is rather obscure because so few specimens are known. These six species certainly do not belong to Platyclymenia, which is considerably more evolute, and has simple concave growth-lines. Similarly Cyrtoclymenia is no suitable home for this group because coeval representatives of that genus all have a subglobose shell form, are subinvolute (Pl. 5.34, Figs. 1-7) and have different growth-lines. Species of Gen. Nov. F (Pl. 5.30, Figs. 1-11) which are also coeval, are much smaller with a more compressed discoidal shell form, and differently shaped growth-lines. A single specimen of Prot. enkebergensis is illustrated here, Pl. 5.34, Figs. 9,10, Textfig. 5.17A.

Horizon and distribution: These six species are known only from the Sauerland, in the delphinus and annulata Zones.

Family Rectoclymeniidae Schindewolf 1923

Type genus: Gen. Nov. D (= Rectoclymenia auctt.).
Diagnosis: Clymeniaceae with involute to subinvolute coiling, compressed to oxyconic shell form, and growth-lines which are biconvex, rectiradiate, with a deep ventral sinus.

Description: Little needs to be added to the diagnosis. Some species are strongly ribbed especially near the umbilicus. The venter can be carinate, tabulate or rounded. The suture is simple, comprising lateral and dorsal lobes or lateral, dorsal and one or two umbilical lobes.

Included genera:

Gen. Nov. D	proposed here (= Rectoclymenia auctt.).
Cteroclymenia	Bogoslovskiy 1979a
Gen. Nov. E	proposed here (= Falciclymenia auctt.).

Remarks: These three genera are distinguished by their sutures, Gen. Nov. D has no umbilical lobe, Gen. Nov. E one, and Ctero-clymenia two. There are two cases here of new names being proposed for what are considered to be invalid genera. One of them is the type genus of the family. Were these proposed names to be accepted the family name might, under the current rules (Code: Art. 40,41), remain unchanged.

Horizon and distribution: Examples are known from the ?sandbergeri Zone to the lower Clymenia Stufe of the Rheinische Schiefergebirge Oberfranken, Thuringia (Germany), Poland, Montagne Noire, southern Urals, North Africa and south east Australia.

Gen. Nov. D

Textfig. 5.19

p	1908	Rectoclymenia gen. nov. - Wedekind, p. 613.
p	1914	Rectoclymenia Wedekind - Wedekind, p. 17.
p	1923a	Rectoclymenia Wedekind - Schindewolf, p. 417.
	1929	Rectoclymenia Wedekind - Lange, p. 84.
	1931	Rectoclymenia Wedekind - Matern, p. 94.
	1957	Rectoclymenia Wedekind - Schindewolf, p. 145.
	1962	Rectoclymenia Wedekind - House, p. 278.
non	1975	Rectoclymenia Wedekind - Bogoslovskiy, p. 35.

Type species: Rect. roemeri Wedekind 1908, proposed here.
Diagnosis: Rectoclymeniidae with rectiradiate, straight or weakly biconvex growth-lines. Simple external suture consisting of broad lateral lobe and ventral saddle.

Description: Shell form discoidal, subevolute, whorl section compressed with flanks flattened and usually strongly ribbed. Venter rounded, tabulate or carinate. Growth-lines are prorsiradiate, straight or biconvex with a ventral sinus.

Available specific names include:

	roemeri	Wedekind 1908, p. 613, pl. XLIII, figs. 9,a.
?	acuta	Perna 1914, p. 66, pl. IV, fig. 9, Fig. 61.
?	acuta	Schmidt 1924, p. 128, pl. 6, figs. 30,a.
	arietina	Sandberger 1853a, p. 182, pl. VII, figs. 5a-c.
	brilonensis	Lange 1929, p. 84, pl. 2, figs. 21a, fig. 20.
	costata	Perna 1914, p. 69, pl. IV, figs. 10a,b.
	flexuosa	Münster 1840, p. 125, pl. XVI, figs. 4a,b.
?	kayseri	Drevermann 1901, p. 135, pl. XIII, fig. 11.
	rotundata	Schindewolf 1923a, p. 419, pl. XVII, fig. 3.

Remarks: It is considered that a new name is required to replace Rectoclymenia Wedekind 1908, as it is now interpreted (Schindewolf, 1957). This was established without a type species, and included the following species: kayseri Drevermann, roemeri sp. nov., arietina Sandberger, steinmanni sp. nov., annulata Münster, crassicosta sp. nov. and protacta sp. nov. Clymenia annulata had already been designated as the type species of Platyclymenia Hyatt (Frech 1902). Frech, Wedekind and Hyatt (who cited Gümbel 1863) all seem to have interpreted annulata in the same way, and so it is argued that Rectoclymenia should be treated as a synonym of Platyclymenia Hyatt, because Wedekind included annulata within it.

Matern (1931, p. 34) erected Rect. roemeri as the type species of Rectoclymenia, which has been accepted by three subsequent authors (see synonymy). To ensure continuity of understanding of this genus Rect. roemeri is proposed as the type species. This genus is restricted to include only those forms showing growth-lines similar to those on the Rect. roemeri type species. This was described from five specimens (Wedekind 1908) and the illustrated specimen (pl. XLIII, figs. 9,a) is proposed as the lectotype. The ribs visible on this are radial and straight. Kind (1944, pl. 1, fig. 10) and Bogoslovskiy (1962, pl. XXXII, figs. 1,a,b) have both figured similar examples, and the specimens figured by Wedekind (1914, pl. 1, figs. 2d-e) as subflexuosa, and by Perna (1914, pl. IV, figs. 10a,b) as subflexuosa, and by Perna (1914, pl. II, figs. 21a,b) as costata (a junior homonym of costata Münster) may also belong here. Large examples (Bogoslovskiy 1962, Wedekind 1914) appear to develop a carinate venter and compressed whorl section and to lose their ribbing, except in the umbilical region.

A single specimen from the type series of Cl. arietina has been located in Wiesbaden, This (Pl. 5.31, Figs. 9,10) was figured by Sandberger (1853b, pl. VII, fig. 13). The better specimen figured in his (?) earlier account (1853a, pl. VII, fig. 5) does not now seem to be in Wiesbaden. It is shown with radial weakly biconvex ribs, which swing sharply backwards over the carinate venter. However the specimen figured here has concave prorsiradiate ribs, and is clearly not conspecific. The species is best interpreted by reference to Wedekind's figure (1914, pl. I, figs. 3a-b), rather than Frech's (1902, pl. II(I), fig. 9).

The only other ribbed species is kayseri (Drevermann 1901), a synonymy for which was given by Lange (1929, p. 97). The lectotype (Drevermann 1901, pl. XIII, figs. 11a-c) is now missing from Marburg. It was small (D=16) evolute, compressed and had 14 straight, radial, blunt ribs in the last whorl. Another example was figured by Wedekind (1914, pl. 1, fig. 4), collected from the delphinus Zone, which was more densly ribbed, especially in the last quarter of a whorl where the ribs are twice as frequent as on the lectotype, and prorsiradiate. Three further examples were figured by Schindewolf (1923a, pl. XVII, fig. 1) which all showed different rib densities, ranging from ca 12 per whorl to ca 20. These three specimens, all on one block, cannot now be traced. Schindewolf collected the specimens from Bed 9 at Kirch-Gattendorf, together with Pseudoclymenia sandbergeri, indicative of the sandbergeri Zone.

Two examples from Geuser are figured here (Pl. 5.31, Figs. 7,8). One (Fig. 8) closely resembles the Drevermann specimens, with few (ca 14 per whorl) radial ribs. The other (BSP AS VII 523), which is more like Schindewolf's specimens, has about 20 ribs per whorl at a diameter of 10mm, and these are weakly concave and prorsiradiate.

In 1924 Schmidt (pl. 6, figs. 30,a) described an evolute oxyconic specimen as Cyrtoclymenia acuta. The holotype, from the Clymenia or Wocklumeria Stufen of Ense, Wildungen, is poorly preserved and shows only the shell form and the semicircular lateral lobe. If this is a Gen. Nov. D, and without knowledge of the growth-lines there can be no certainty, then its specific name is preoccupied by Cl. acuta Perna (1914, p. 65, pl. IV, fig. 9, textfig. 61) which has an oxyconic subinvolute shell form and weakly biconvex prorsiradiate growth-lines.

Two specimens from Beil are intermediate in age and shell form between other Gen. Nov. spp. and ?Gen. Nov. acuta sensu Schmidt. These, GT 2015 and KW 2076 (Pl. 5.31, Figs. 13-16), have similar shell form, evolute with converging flanks and a subtriangular whorl section. GT 2015 has growth-lines which are weakly biconvex, or concavo-convex. There are no ribs, but the growth-lines are periodically bunched. The specimen was collected from the delphinus Zone at Beil. KW 2076 was collected higher in the sequence, probably from the lower Clymenia Stufe, and has growth-lines which are weakly concave at a diameter of ca 50mm, but these become weakly convex on the body chamber, at a diameter of 70mm. A groove runs along the ventro-lateral shoulder of the internal mould and the suture is illustrated (Textfig. 5.19D).

Dimensions:

	D	U	WW	WH
Wsb, Pl.5.31, Figs.9,10.	27	9.4		10.9
kayseri, BSP AS VII 523	15.1 12.4	6.1 5	3.6	4.5 4.4
acuta Schmidt, MfN, Pl.5.31, Figs.4-6.	31.3	13	5	11.4
GT 2015	43.5		7.3	19.5
KW 2076	75.2 51.5	27.8 20.0	ca17	29.1 19.3

Horizon and distribution: Gen. Nov. D is known from Sauerland, Kellerwald, Oberfranken and s. Urals, and ranges in age from

?sandbergeri Zone (kayseri) to the lower Clymenia Stufe.

Gen. Nov. D flexuosa (Münster 1840)

Pl. 5.31, Figs. 1,2, Textfigs. 5.19E-F

*	1840	Clymenia flexuosa sp. nov. - Münster, p. 125, pl. XVI, figs. 4a,b.
non	1842	Clymenia flexuosa var. costata nov. - Münster, p. 92, pl. XI, figs. 16a,b.
non	1863	Clymenia flexuosa Münster - Gümbel, p. 126.
non	1902	Clymenia flexuosa Münster - Frech, p. 32, textfig. 2.
	1923a	Rectoclymenia rotundata sp. nov. - Schindewolf, p. 419, pl. XVII, fig. 3.
non	1923a	Cyrtoclymenia flexuosa Münster - Schindewolf, p. 425.

Type material: A neotype, BM 81856, from Geuser, Oberfranken, is proposed.
Remarks: No material from the type series has been located. The neotype is from the same locality as Münster's material.
Diagnosis: Gen. Nov. D with compressed shell form, narrow flatly rounded venter, biconvex growth-lines bunched to form ribs, especially near the umbilicus.

Description: Two specimens were examined, the neotype (Pl. 5.31, Fig. 2), and Mbg 3121, which is the lectotype (proposed here) of Rect. rotundata Schindewolf, 1923a (Pl. 5.31, Fig. 2).

The neotype (BM 81856) has a shell form which is discoidal, subinvolute, the umbilicus amounts to 26% of the diameter at a diameter of 17.8mm. The whorl section is compressed with the maximum width at the umbilicus, the flanks converge slightly towards the flatly rounded venter. Growth-lines are biconvex with a shallow, broad, mid-flank sinus, and a more prominent ventro-lateral salient. Growth-lines are bunched to form flat ribs, especially near to the umbilicus. The suture is not visible.

The lectotype of <u>Rect</u>. <u>rotundata</u> has a similar shell form, but has growth-lines which are more truly biconvex withboth flank salients being equally prominent, and the mid-flank sinus being very shallow. However, this distinction may be enhanced by the fact that BM 81856 is distorted. Flat ribs are present, composed of ca 10 growth-lines, which have a frequency of ca 100 per centimetre, at a diameter of 22mm. Part of a radial constriction is visible on the internal mould.

Dimensions:

	D	U	WW	WH
Neotype, BM 81856	17.8	4.7	-	8.6
Mbg 3121 (distorted)	22	4.2		10

Discussion: In spite of the fact that Münster's original description and figure were quite unambiguous there has been much incorrect interpretation of this species, hence the need for the establishment of a neotype. The confusion has arisen from a failure to identify the specimens figured by Münster. Gümbel (1863) illustrated four examples as <u>Cl</u>. <u>flexuosa</u> in pl. XV. That illustrated in fig. 7 was wrongly claimed to be the original of <u>Cl</u>. <u>flexuosa</u> Münster. This is clearly not so since it has strong ribbing. Figure 8 resembles the specimen of <u>Cl</u>. <u>falcifera</u> figured by Münster (see below), <u>Cl</u>. <u>costulata</u>, the original of which Gümbel claimed to have illustrated in fig. 9, was not figured by Münster, and fig. 10 has been designated as the lectotype of Gen. Nov. <u>F</u> <u>subflexuosa</u>. Gümbel also mentioned <u>Cl</u>. <u>flexuosa</u> var. <u>costata</u>, but did not illustrate any examples. The inclusion of such different specimens within <u>Cl</u>. <u>flexuosa</u> has been the cause of its broad interpretation.

Frech (1902) examined specimens of <u>Cl</u>. <u>falcifera</u> and <u>costulata</u>

in Berlin, and declared them to be identical with the original of Cl. flexuosa. He figured (1902, fig. 2) a large (D=55) sketch of Cl. flexuosa, itself a composite of a specimen from Planitz, Saxony, and another from Cabrières. The larger example is evolute with concave, rursiradiate growth-lines, and is best described as a Platyclymenia.

Schindewolf (1923a) examined four specimens in the Münster Collection at Munich and attempted to resolve the problem of the identity of Cl. flexuosa. He recognised Cl. subflexuosa to be a distinct species (see below). He selected (1923a, p. 425) the specimen figured by Münster (1842) in pl. XI, figs. 16a,b on which to base his description of Cl. flexuosa. Unfortunately this (Pl. 5.30, Figs. 6,7) has concavo-convex growth-lines and prominent lunate ribs near the umbilicus and was described by Münster as Cl. flexuosa var. costata. Cl. costulata was not mentioned by Schindewolf, and he considered the strongly ribbed evolute Cl. falcifera Münster to be identical with Cl. flexuosa (p. 419).

My conclusions from examining the same specimens are:

1. Gen. Nov. D flexuosa is a species defined by reference to Münster 1840, pl. XVI, figs. 4a,b. A neotype (BM 81856) has been selected.
2. Gen. Nov. F costata is a species identified by its lectotype BSP AS VII 606, which was figured by Münster 1842, pl. XI, figs. 16a,b, and is described below.
3. Gen. Nov. F falcifera is a species identified by comparison with Münster 1842, pl. XI, figs. 17a,b and Gümbel 1863, pl. XV, figs. 8a-d and interpreted by the neotype illustrated in Pl. 5.30, Figs. 8,9 (see below).
4. Cl. costulata is treated as a nomen dubium; the original

description is brief, and no type material has been located (but see Gen. Nov. F falcifera, below).

The species described as Rect. rotundata by Schindewolf (1923a) differs only in having slightly more biconvex growth-lines, but this apparent distinction may be due simply to the distortion of the neotype.

Comparisons: Gen. Nov. D brilonensis Lange, 1929, described from the delphinus Zone at Enkeberg has a much thicker whorl section, and is more widely umbilicate.

Horizon and distribution: Schindewolf (1923a) reported Rect. rotundata from IIIβ (Bed 11, Kirch-Gattendorf). The species is known only from Oberfranken (W. Germany).

Gen. Nov. E

Textfig. 5.19

?p	1923a	Falciclymenia gen. nov. - Schindewolf, p. 419.
	1923b	Falciclymenia gen. nov. - Schindewolf, p. 64, fig. 4f.
?	1935	Pseudoclymenia Frech - Böhm, p. 58.
non	1951	Falciclymenia Schindewolf - Miller and Collinson, p. 600.
	1957	Falciclymenia Schindewolf - Schindewolf, p. 145.
?p	1960	Falciclymenia Schindewolf - Kullmann, p. 541.
	1960	Falciclymenia Schindewolf - Bogoslovskiy, p. 72.
	1962	Falciclymenia Schindewolf - Bogoslovskiy, p. 407, pl. XXXII, figs. 2a,b.
	1973	Falciclymenia Schindewolf - Brugge, pl. 1, figs. 1-4.

Type species: sp. a, described below.

Diagnosis: Rectoclymeniidae with sickle-shaped external suture (Textfig. 5.19M).

Description: Shell form compressed, discoidal, subinvolute, venter narrow, tabulate or carinate merging with flanks. Growth-lines prorsiradiate biconvex with ventral sinus. Ribbing present. Suture consisting of three lobes, a deep rounded lateral lobe, a shallow umbilical lobe, and a narrow tongue-shaped dorsal lobe. Gen. Nov. E uralica (Bogoslovskiy 1960) is the only existing species certainly assigned to this genus. Two unnamed species are described here, and cyrtostriata Kullmann may belong here, too.

Discussion: This new genus is introduced in order to clear up confusion surrounding Falciclymenia, established by Schindewolf in 1923 (see synonymy above), with type species falcifera Münster, and considered to be a junior subjective synonym of Protornoceras Dybcynski 1913.

An ambiguity arises in interpreting the type species. Münster had used the specific name falcifera for Famennian ammonoids twice: Goniatites falcifer 1840, p. 106, pl. XVI, fig. 7, and Clymenia falcifera 1842, p. 125, pl. XI, figs. 17a,b. The earliest mention of Falciclymenia is in a footnote (Schindewolf 1923a, p. 419), where Rect. falcifera Münster is named as its type species. This, in turn, refers to G. falcifer Münster. Schindewolf noted that Frech (1902) had already recognised this to be a clymeniid, synonymous with Cl. subflexuosa Münster, and he had illustrated an example from La Serre (1902, pl. V(IV), figs. 4,a). Schindewolf contradicted this opinion, stating that he had compared the originals of subflexuosa and falcifera with a further example from Cabrières (La Serre). This last specimen, which "... zeigt zu Beginn des letzten Umganges fast gerade runde radial Rippen", is believed to have been collected by Escot, and is now in the collections at Marburg, and is illustrated here in Pl. 5.32, Figs. 10,13,14, where the ribbing and the suture can be seen clearly. Its provenance is discussed below.

Later Schindewolf (1923b, fig. 4f) illustrated a sickle-shaped suture for this species, the derivation of the illustrated specimen being "Oberdevon IV, Cabrières". This is also probably based on the specimen referred to above.

Schindewolf (1923a, p. 419) referred Cl. falcifera Münster 1842 to Cyrt. flexuosa. This latter species, described above as Rect. flexuosa lacks the strong sickle-shaped ribs visible on Münster's figure, and so falcifera is recognised as a different species, assigned to Gen. Nov. D.

It seems, therefore, that the type species of Falciclymenia Schindewolf is G. falcifer Münster 1840, the original figure and account of which was based on a single specimen. This describes a discoidal, subinvolute ammonoid with a tabulate venter and a sickle-shaped suture. Small tubercles/ribs are visible near the umbilicus of inner whorls but otherwise the shell surface is smooth. Gümbel (1863, pl. V, fig. 3) described what he considered to be the same specimen, but noticed "strongly curved striations" on the flank. His figure of the suture shows a deep rounded lateral lobe and a narrow dorsal lobe. Schindewolf (1923a), in mentioning the original of G. falcifer, described the course of the suture, and weak sickle-shaped growth-lines.

No specimen can be located today in Munich which is identical with all of these authors' descriptions; BSP AS VII 528, described below, comes close to Gümbel and Schindewolf's descriptions in having the correct shell form, ornament and suture, but lacks the tubercular ornament of inner whorls, which was mentioned by Münster. Therefore, there is no holotype.

Considering the original figure, the most likely identification of falcifer Münster, is as a Protornoceras. An example of Protornoceras (RE 551 734.5 A242/1) from Enkeberg, is shown in Pl. 5.32, Figs. 4,5. This has an external suture which could be described as falcate (Textfig. 5.19H), a compressed, discoidal shell form, and ribbing, visible especially near to the umbilicus. Kayser (1873) used the name _falcifer_ Münster for a species from Enkeberg, renamed _dorsatum_ by Wedekind (1908), which is now recognised (Bogoslovskiy 1971) as a _Protornoceras_, so this interpretation of _falcifer_ Münster has been used before, although long since ignored.

Accepting this interpretation of _G. falcifer_, _Falciclymenia_ must be interpreted as a junior synonym of _Protornoceras_ Dybcynski. A new name is required, therefore, for forms which Schindewolf and subsequent authors have named as _Falciclymenia_.

The only author to have discussed _Falciclymenia_ in detail is Kullmann (1960). Here he described a new species, _cyrtostriata_, with a falcate suture and shell form similar to sp. _a_ (see below), but with falcate growth-lines which have a very large prominent ventro-lateral salient, in contrast to the weakly biconvex growth-lines of sp. _a_. Similar differences in growth-line course are used here to distinguish Gen. Nov. _D_ (= _Rectoclymenia_) from Gen. Nov. _F_, so by the same argument _cyrtostriata_ could be excluded from Gen. Nov. _E_, and would, by implication, require a genus of its own. It is the opinion of Korn (pers. comm.), who has examined Kullmann's specimen, that _Falc. cyrtostriata_ may be a _Cymaclymenia_. The side of the specimen from which the figure of the suture was drawn is weathered, and thus may not be a true representation of the suture.

The other species which Kullmann included in _Falciclymenia_ are excluded from Gen. Nov. _E_. These include _falcifera_ Münster, _pernai_ Nalivkina (1953, p. 110, pl. IV, fig. 11), and _gracilis_ Nalivkina (1953, p. 111, pl. IV, fig. 14). Neither has a truly falcate external suture, the flat umbilical saddle being absent. The illustration of gracilis shows growth-lines and ribs which are concavo-convex rather than biconvex; both are included here in Gen. Nov. F.

It has already been argued elsewhere (see Endosiphonites (Endosiphonites) above) that bowsheri Miller and Collinson (1951), a plaster cast of which (SM H7366) is figured here (Pl. 5.33, Figs. 8,9) is not a Falciclymenia.

Horizon and distribution: Gen. Nov. E is known from the Platyclymenia Stufe of Thuringia, Oberfranken, Montagne Noire, and the annulata Zone in the southern Urals. The only surely dated specimens are those described by Brügge (1973) who recorded examples from around the annulata Zone/Clymenia Stufe boundary in Thuringia.

Gen. Nov. E sp. nov. a

Pl. 5.33, Figs. 10,13,14, Textfigs. 5.19M,N

?	1902	Clymenia subflexuosa Münster - Frech, p. 34, pl. V(IV), fig. 4.
	1923b	Falciclymenia falcifera sp. nov. - Schindewolf, p. 64, fig. 4f.
?	1935	Pseudoclymenia (?) sp. - Böhm, p. 58, pl. II, figs. 1a,b.
v?	1973	Falciclymenia falcifera Münster - Brügge, pl. 1, figs. 1-4.

Holotype: An unnumbered specimen from Marburg, collected by Escot.
Type locality: La Serre, Cabrières, Hérault, horizon unknown but is probably the annulata Zone or Clymenia Stufe.
Diagnosis: Gen. Nov. E with subinvolute shell, discoidal shell form, subcarinate venter, weakly biconvex growth-lines and weak radial ribs, developed in early whorls and retained only near the umbilicus on the body chamber of the holotype.

Description: The holotype, illustrated in Pl. 5.33, Figs. 10,13, 14, and Textfigs. 5.19M,N, is a large specimen, preserved in dark red micrite with replaced shell, dissolved in places to reveal the septa.

The shell form is discoidal, subevolute, with the umbilical width amounting to 25% of the diameter, at a diameter of 62mm. The whorl section is shown in Textfig. 5.19N, based on a section which is slightly off-centre. The umbilical wall is inclined at 45^{o} to the flanks of the previous whorl. The flanks, which, at a diameter of ca 30mm, are composed of two concave portions with the greatest whorl width at a position midway between umbilicus and venter, become flat with the maximum width at the umbilicus by a diameter of 50mm. Over this interval the venter changes from being flatly arched to subacute, bounded by two shallow grooves.

Growth-lines are prorsiradiate, weakly biconvex at a diameter of 45mm (Textfig. 5.19M) with a very deep narrow ventral sinus, but appear to be concavo-convex prior to this point. Up to a diameter of ca 40mm radial concavo-convex ribs are present, but these gradually diminish in strength to give weak umbilical tubercles at the same position as the last, approximated septa, and are not present at all on the body chamber, which extends for half a whorl.

The falcate external suture with narrow angular ventral saddle is illustrated in Textfig. 5.19M; the internal suture is unknown.

Remarks: It has already been argued that this specimen is probably the one which Schindewolf (1923b) used to illustrated the suture of Falciclymenia and which he had described earlier (1923a). The holotype bears only a superficial resemblance to G. falcifer Münster 1840, which Schindewolf had named as the type species of Falciclymenia, but it is probably this well preserved specimen which Schindewolf had in mind when he erected his new genus.

The two specimens (MfN c429 ,1,3) from Schleiz, which Brügge illustrated as Falc. falcifera (1973, pl. 1, figs. 1-3, 4) clearly show a falcate suture like the holotype, and have a similar whorl section. Both specimens are very weathered internal moulds; one (c429.3) may show weak indications of ribs (Pl. 5.33, Figs. 10,11) and so they cannot certainly be included here. Brügge provided no description of these specimens.

The single fragment of a large specimen which Frech (1902, pl. V(IV), fig. 4) illustrated as Cl. subflexuosa, from La Serre, Cabrières the type locality of sp. a, has a falcate external suture, and an oxyconic shell form. It may represent a weathered example of this species, but it is too poorly preserved to be certain, nor can the material be traced.

The specimen figured by Böhm (1935, pl. II, figs. 1a,b) as Pseudoclymenia (?) sp., also collected from La Serre, probably belongs here. It is weathered, but has the same shell form and suture as the holotype.

Dimensions:

	D	U	WW	WH
Holotype, Mbg	62	16.6	11.5	ca28
	40	11	10.9	23

Horizon and distribution: The horizon of the holotype is unknown, but dark red limestones at La Serre range through the Platyclymenia and Clymenia Stufen. Brügge's specimens are from the annulata Zone/Clymenia Stufe boundary. The species is known with certainty only from Thuringia and the Montagne Noire.

? Gen. Nov. E sp. b

Pl. 5.31, Fig. 3, Textfig. 5.190

Holotype: BSP AS VII 528.
Type locality: Geuser, Oberfranken.
Diagnosis: Gen. Nov. E with lirate biconvex growth-lines, and a tabulate venter.

Description: Only the holotype has been seen. This is preserved in grey micrite, weathered, and has been polished to show the suture. It (Pl. 5.31, Fig. 3) is subevolute with an umbilical width amounting to 25% of the diameter, at a diameter of 20mm. The whorl section is compressed with flattened flanks and a tabulate venter, which is now filed. Growth-lines are lirate, slightly prorsiradiate and biconvex. The external suture (Textfig. 5.190) is falcate over the flank, but its course over the venter is not visible.

Dimensions:

	D	U	WW	WH
BSP AS VII 528	19.5	5.5	4.8	8

Remarks: There is no conclusive evidence to show that this specimen is not a Protornoceras, although there is no known species with which it can be compared.

Horizon and distribution: This unique museum specimen is from Geuser, Oberfranken. Other specimens collected from Geuser are considered to come from the Platyclymenia Stufe.

Family Carinoclymeniidae Bogoslovskiy 1975

Type genus: Carinoclymenia Bogoslovskiy 1965
Diagnosis: Clymeniaceae with subinvolute to subevolute coiling, compressed or oxyconic shell form and growth-lines which are prorsiradiate, concavo-convex or biconvex with a very prominent ventro-lateral salient. The suture has a high ventral saddle, usually split by a shallow lobe, a broad lateral lobe, sometimes an umbilical lobe, and a dorsal lobe.

Included genera:

Gen. Nov. F	proposed here
Carinoclymenia	Bogoslovskiy 1965
Pinacoclymenia	Bogoslovskiy 1975

Remarks: Bogoslovskiy (1975) erected this family to contain genera with a compressed or oxyconic shell form, growth-lines with a prominent ventro-lateral salient, and with a shallow ventral lobe. This latter feature may simply be a function of the shell form. Here emphasis is placed on the growth-line shape. Species with concavo-convex growth-lines, including a prominent ventro-lateral salient, which formerly have been treated as Rectoclymenia or Cyrtoclymenia, are included here in Gen. Nov. F. These are small, distinctive species, often strongly ribbed.

Comparisons: These three genera can be distinguished by the sutures and growth-line course; only Gen. Nov. F has concavo-convex growth-lines, Carinoclymenia has biconvex growth-lines and Pinacoclymenia has biconvex growth-lines and two umbilical lobes.

Horizon and distribution: Examples are known from the delphinus to paradoxa Zones of the Rheinische Schiefergebirge, Oberfranken, Thuringia (Germany), Poland, the southern Urals and Montana (USA).

Gen. Nov. _F_

Textfig. 5.20

p	1908	_Protactoclymenia_ gen. nov. - Wedekind, p. 608.
p		_Rectoclymenia_ gen. nov. - Wedekind, p. 613.
p	1914	_Rectoclymenia_ Wedekind - Wedekind, p. 17.
p		_Protactoclymenia_ Wedekind - Wedekind, p. 20.
p	1914	_Clymenia_ Münster - Perna, p. 9.
p	1923a	_Rectoclymenia_ Wedekind - Schindewolf, p. 417.
p		_Cyrtoclymenia_ Hyatt - Schindewolf, p. 421.
p	1924	_Lenticlymenia_ gen. nov. - Schmidt, p. 126.
p	1931	_Rectoclymenia_ Wedekind - Matern, p. 94.
?	1953	_Rectoclymenia_ Wedekind - Nalivkina, p. 100.
?		_Cyrtoclymenia_ Hyatt - Nalivkina, p. 101.
p	1960	_Falciclymenia_ Schindewolf - Kullmann, p. 538.
?	1962	_Rectoclymenia_ Wedekind - House, p. 278.
	1975	_Rectoclymenia_ Wedekind - Bogoslovskiy, p. 36.

Type species: _Protactoclymenia lotzi_ Wedekind 1908 (= _Cl. stuckenbergi_ Tokarenko).
Diagnosis: Carinoclymeniidae with prorsiradiate concavo-convex growth-lines.

Description: Commonly small (D <25mm), with evolute to subinvolute coiling. Whorl section is compressed, quadrate or pear-shaped, with subparallel flanks. The venter may be tabulate, grooved with longitudinal ventro-lateral flares, or carinate. Growth-lines are prorsiradiate concavo-convex with a prominent ventro-lateral salient. Ribbing is common and generally confined to the concave portion of the growth-lines. The suture consists of a dorsal lobe, broad lateral lobe and ventral saddle, which may be subdivided by a lobe.

The following species are included:

*	_lotzi_	Wedekind 1908, p. 611, pl. XLIII, figs. 8a-c.
	costata	Münster 1842, p. 125, pl. XI, figs. 16a,b.

	costulata	Münster 1839, p. 94.
	falcifera	Münster 1842, p. 125, pl. XI, figs. 17a,b.
?	finitima	Bogoslovskiy 1975, p. 304, pl. VI, figs. 3,4.
	glabra	Perna 1914, p. 69, pl. III, figs. 4a,b.
?	gracilis	Nalivkina 1953, p. 111, pl. IV, fig. 14.
?	haynesi	House 1962, p. 278, pl. 47, figs. 1-3, textfigs. 13A,B.
	minuta	Kind 1944, p. 150, pl. 1, fig. 5.
	orientalis	Perna 1914, p. 67, pl. III, figs. 7a,b.
	ornata	Kind 1944, p. 150, pl. 1, fig. 6.
?	pernai	Nalivkina 1953, p. 110, pl. IV, fig. 11.
	pinnatiformis	Nalivkina 1953, p. 108, pl. IV, fig. 10.
	stuckenbergi	Tokarenko 1903, p. 31, pl. III, fig. 4.
	subflexuosa	Münster 1840, p. 93.
?	tuberculata	Kind 1944, p. 152, pl. 18, fig. 8.

Remarks: Few of these species are well known to me, either because little material is available, or the original illustrations and descriptions are poor, and also two-thirds of the "species" were described in Russian. Two of the species, gracilis and pernai, were assigned to Cyrtoclymenia by Nalivkina (1953) but later treated as Falciclymenia by Kullmann (1960). They develop weak saddles just outside the umbilical seam, but these are not as broad as in other species of "Falciclymenia", (see Gen. Nov. E), above. Their shell form and ornament resembles other species included in this group.

Comparison: Their small size, subinvolute coiling, compressed shell form and concavo-convex growth-lines distinguish numbers of this genus from Cyrtoclymenia. The Rectoclymeniidae all have biconvex growth-lines.

Horizon and distribution: Examples are known ranging from the delphinus Zone to the ?paradoxa Zone. Most species have been reported from the Platyclymenia Stufe of the Rheinische Schiefergebirge, Oberfranken (Germany), s. Urals and Kazakhstan (USSR).

Schindewolf (1937a) listed a species "Cyrtoclymenia sp. nov. (cf. stuckenbergi Tokarenko)", as occurring in the sphaeroides Subzone at Oberrödinghausen, which is considerably younger than any other records. The species was neither described nor illustrated.

Gen. Nov. F stuckenbergi (Tokarenko 1903)

Pl. 5.30, Figs. 1,2, Textfigs. 5.19A-C

* 1903 Cl. stuckenbergi sp. nov. - Tokarenko, p. 31, pl. III, figs. 4,a,b.

1908 Protactoclymenia lotzi sp. nov. - Wedekind, p. 611, pl. XLIII, figs. 8,a-c.

1914 Cl. stuckenbergi Tokarenko - Perna, p. 68, pl. III, figs. 1-3, pl. IV, figs. 11,16, textfigs. 64,5.

1914 Protactoclymenia lotzi Wedekind - Wedekind, p. 23, pl. 2, figs. 13-15.

1924 Lenticlymenia lotzi Wedekind - Schmidt, p. 126.

1944 Cyrtoclymenia stuckenbergi Tokarenko - Kind, p. 151, pl. 1, figs. 7,a.

1953 Cyrtoclymenia stuckenbergi Tokarenko - Nalivkina, p. 105, pl. IV, fig. 5, textfig. 30.

Type material: The specimen figured by Tokarenko is proposed as the lectotype.

Diagnosis: Gen. Nov. F with distinctive compressed whorl section, grooved venter with longitudinal ventro-lateral flares and concavely ribbed flanks.

Material: Two specimens from Beil, GT 2016 (Textfig. 5.19B) and KW 2058 (Pl. 5.30, Figs. 1,2, Textfig. 5.19C).

Description: Shell form subevolute (U/D = 0.30) with a compressed whorl section (WW/WH = ca 0.6) with the flanks converging from the maximum width at the umbilical shoulder. The venter is grooved and longitudinal flares form at the ventro-lateral shoulder; these are visible, preserved as stumps on cross-sections of enveloped whorls (Textfig. 5.19C). The concavo-convex growth-lines and ribs, continued to the inner part of the flank, are shown in Textfig. 5.19B, and the broad lateral lobe of the suture is shown in Textfig. 5.19A.

Discussion: Perna (1914) first noticed the similarity between this species with Prot. lotzi Wedekind, of which the specimen illustrated (Wedekind 1908) in pl. XLIII, fig. 8,a,b, is proposed as the lectotype. Nalivkina (1953) indicated that it had a shallow ventral lobe (Textfig. 4.14G). This feature has not been observed on either of the specimens illustrated here.

Dimensions:

	D	U	WW	WH
Tokarenko 1903, p. 31.	20		5.5	7.5
	15		4.5	6.5
Wedekind 1914,p.23.	20.5	6.9	5.5	8
Perna 1914, p. 68.	20	7	5.4	7.2
GT 2016	20	5.9	4.8	8.3
	13.7	3.7	3.8	5.9
	9.2	2.2	2.7	4.3
	6.2	1.3	2.1	2.9
KW 2058	19.8	5.4	5.8	7.4

Horizon and distribution: The two specimens described here were collected from the (?) delphinus Zone at Beil, Sauerland. The species is also known from the same horizon in the southern Urals.

Gen. Nov. F *falcifera* (Münster 1842)

Pl. 5.30, Figs. 3,4,8, Textfig. 5.19P

(?) 1840 *Clymenia decorata* sp. nov. - Münster, p. 91

* 1842 *Clymenia falcifera* sp. nov. - Münster, p. 125, pl. XI, figs. 17a,b.

p 1863 *Clymenia flexuosa* Münster - Gümbel, p. 128, pl. XV, figs. 5a-d.

p 1923a *Cyrtoclymenia flexuosa* Münster - Schindewolf, p. 425.

non 1923a *Falciclymenia falcifera* Münster - Schindewolf, p. 418, and all references below to Gen. Nov. E.

Type material: BSP AS VII 533, from Geuser, Oberfranken, is proposed as the neotype.

Remarks: This particular specimen had adhering to it a label in Münster's handwriting, which said "*Cl. decorata*". This species was introduced simply as a name in a list, as *Cl. ornata* var. *decorata* (1840, p. 91), without a description of its character. It is therefore regarded as a *nomen dubium*. The neotype agrees completely with the figure which Münster (1842) gave for *Cl. falcifera*.

Diagnosis: Evolute Gen. Nov. F, with compressed whorl section and tabulate venter. Early whorls have strong almost tuberculate ribs at the umbilicus, growth-lines are prorsiradiate concave, becoming concavo-convex, almost falcate.

Description: Two specimens, the neotype (Pl. 5.30, Figs. 4,8) and another specimen from Geuser in the Münster Collection at Berlin, were available for study.

Both specimens are preserved in matrix so the shell form cannot be accurately described. Coiling is evolute (U/D = 0.45). The whorl section seems subcircular in early whorls but becomes compressed on the last whorl seen, at a diameter of ca 8mm. Ornament consists of strong lirate growth-lines, present throughout all preserved growth stages (D = 1.5-11mm). Early whorls have concave prorsiradiate growth-lines and strong annular ribs (Pl. 5.30,

Fig. 4). By a diameter of 5.5mm the neotype has no ribbing, only concavo-convex (Textfig. 5.19P) growth-lines, but the Berlin example has thicker growth lirae and vestiges of ribbing near the umbilicus.

Dimensions:

	D	U	WW	WH
Neotype, BSP AS VII 533.	10.9	4.9	-	3.7

Remarks: The ornament by which this species can be separated both from Rect. flexuosa and Gen. Nov. E (formerly Falciclymenia falcifera) was discussed at length above. Clymenia costulata Münster 1839 (p. 94) described as "distinguished from Dunkeri by ring-shaped tubercled ribs without striations between, in outer whorls the tubercles are weaker and almost disappear", may be a senior synonym of this species, but since it was never illustrated nor more precisely described it is better to give priority to falcifera.

Horizon and distribution: This species is only known from the ?sandbergeri Zone at Geuser, Oberfranken.

Gen. Nov. F costata Münster 1842

Pl. 5.30, Figs. 6,7, Textfig. 5.19D

v 1842 Clymenia flexuosa var. costata nov. - Münster, p. 125, pl. XI, figs. 16a,b.
non 1923a Rectoclymenia flexuosa Münster - Schindewolf, p. 425.

Type material: BSP AS VII 606 from Geuser, Oberfranken, is recognised as the lectotype.

Remarks: There can be no doubting that the lectotype was accurately

illustrated by Münster 1842.
Diagnosis: Gen. Nov. F with subinvolute shell form, compressed flanks, tabulate venter, and prominent lunate ribs, confined to the inner half of the flank, and disappearing on the body chamber of mature examples.

Description: Only the lectotype has been seen. It is preserved in grey micrite and distorted (Pl. 5.30, Figs. 6,7, Textfig. 5.19D). The umbilical width amounts to 30% of the diameter, at a diameter of 20.3mm. The whorl shape, visible in the last third of a whorl, is compressed with flattened flanks converging from a maximum width at the umbilical shoulder, towards the tabulate venter. Ornament is visible only on the last half whorl. Here there are four widely spaced lunate ribs. These have a central depression (Textfig. 5.19D) giving the appearance of there being two ribs fused at either end. Over the last quarter whorl the ribs are prorsiradiate narrower, subdued and much closer together, but can be seen extending over the ventro-lateral salient into a U-shaped ventral sinus. Only a portion of the suture (Textfig. 5.19D) is preserved, but this seems to show a broad lateral lobe.

Dimensions:

	D	U	WW	WH
Lectotype, BSP AS VII 606	20.3	5.9	4.5	8.1
	15	3.8	4	5.8

Remarks: There have been no references to this species since its initial description. Only pinnatiformis Nalivkina (1953) has similar ribs but this has a pear-shaped whorl section. Two other specimens from Geuser are referred to Gen. Nov. F aff. costata. BSP AS VII 529 (Pl. 5.30, Fig. 5) differs in having a ventro-lateral groove a longitudinal ornament and a much narrower umbilicus. The same features are found on HU P82.21 except that this lacks the groove in the middle of the ribs.

Horizon and distribution: This species is known only from Geuser, Oberfranken. Conodonts extracted from the matrix of BSP AS VII 529 were dated as older than Middle velifer Zone by Prof. W. Ziegler. This dating suggests an early delphinus Zone age. This is the earliest conodont zone from which clymeniids are known.

Gen. Nov. F subflexuosa (Münster 1840)

Pl. 5.30, Figs. 10,11, Textfigs. 5.19E,F

*	1840	Clymenia subflexuosa sp. nov. - Münster, p. 93.
v	1863	Clymenia subflexuosa Münster - Gümbel, p. 126, pl. XV, figs. 10a-c.
non	1902	Clymenia subflexuosa Münster - Frech, p. 34, pl. V(IV), fig. 4.
p	1908	Protactoclymenia subflexuosa Münster - Wedekind, p. 612.
?	1914	Rectoclymenia subflexuosa Münster - Wedekind, p. 18, pl. I, figs. 2a-c, non 2d-e.
non	1914	Clymenia subflexuosa Münster - Perna, p. 64, pl. II, figs. 21a,b.
v?	1923a	Rectoclymenia subflexuosa Münster - Schindewolf, p. 417, pl. XVII, fig. 2.

Type material: BSP AS VII 526 from Geuser, Oberfranken, is proposed as the lectotype.

Diagnosis: Gen. Nov. F with oxyconic shell form, umbilicus amounting to 25% of the diameter, and concavo-convex prorsiradiate growth-lines.

Description: Only the lectotype has been seen. This (Pl. 5.30, Figs. 10,11) has a shell form which in early whorls (D=3.6, U/D=0.41, WW/WH=1.42) is evolute with a reniform whorl section (Textfig. 5.19F) but by a diameter of 4mm the flanks are compressed and become progressively more so. At a diameter of 15mm the venter is acute, bounded by two shallow grooves, the flanks flat and converging and there is almost no umbilical wall. The ratio WW/WH is 0.51, and the umbilical width amounts to 30% of the diameter which by the maximum diameter of 21.6mm have reduced to 0.38 and 23% respectively.

The growth-lines are concavo-convex, prorsiradiate with a shallow flank sinus and a prominent salient on the ventrad part of the flank, (contra Gümbel's figure 10c), which swings back into a deep sinus over the venter (Textfig. 5.19E). Growth-lines number 150 per centimetre at a diameter of 21mm, where they are separated into groups of ca 25, divided by a few more closely spaced growth-lines, which give the impression of weak ribs, visible especially near the venter. Growth-lines are strengthened over the venter where they form a weak crenulation.

The suture is not convincingly visible in the spar-filled phragmacone, but appears to consist of a simple broad lateral lobe.

Dimensions:

	D	U	WW	WH
Lectotype, BSP AS VII 526	21.6	5	3.4	10
	15.9	4.5	2.65	6.7
	11	3.44	2.18	4.7
	7.2	2.60	1.67	2.88
	5.2	1.95	1.85	1.95
	3.6	1.39	3.8	1.30
Mbg 3021	50.5	11.3	11.6	23.5
BSP AS VII 527	11.2	3.7	2.9	4.4

Discussion: Münster stated (1840, p. 93) that he had found one specimen of this new species, after he had prepared the plates for his latest work, and therefore in this instance it is reasonable to accept Gümbel's statement (1863, p. 163) that he had figured Münster's original. The specimen from La Serre, Hérault, figured by Frech (1902, pl. V(IV), fig. 4) cannot be included here; no ornament is preserved and the suture points to it being either a

"*Falciclymenia*" (see Gen. Nov. *E* below), or a tornoceratid. One of the specimens figured by Wedekind (1914, pl. 1, figs. 2d-e) clearly has biconvex ribs, unlike the lectotype, and so is not included in synonymy with this species, and the other specimen lacks any ornament. The specimen figured by Perna (1914) has a much thicker whorl section and radial biconvex ribs. It is probably synonymous with *Rect*. *roemeri* Wedekind. Schindewolf (1923a) found only one poorly preserved specimen (Mbg 3120); this (Pl. 5.31, Figs. 11,12) lacks ornament and therefore can only questionably be included here.

Another specimen (BSP AS VII 527, Pl. 5.30, Fig. 9) from Geuser generally resembles the lectotype, but differs in having a wider umbilicus (though there is indication of umbilical uncoiling on the lectotype) and a more pronounced ornament; there are periodic ribs which are strongest over the ventro-lateral salient. The carinate venter is bounded by grooves. The suture is not visible.

Horizon and distribution: The species is known from Rheinische Schiefergebirge and Oberfranken. Schindewolf (1923a) recorded his specimen from IIIβ (Bed 11, Kirch-Gattendorf).

Genus *Carinoclymenia* Bogoslovskiy 1965

Textfig. 5.21

1929 ?*Tornoceras* - Lange, p. 49.
1956 *Tornoceras* Hyatt - Müller, p. 51.
* 1965 *Carinoclymenia* gen. nov. - Bogoslovskiy, p. 89.
. 1975 *Acriclymenia* gen. nov. - Bogoslovskiy, p. 306.

Type species: ?*Tornoceras* *beuelense* Lange 1929, p. 49, by original

designation.
Diagnosis: Carinoclymeniidae with sickle-shaped growth-lines, oxyconic shell form and suture with shallow secondary ventral lobe and highly arched ventral saddle, broad lateral lobe and dorsal lobe.

Description: A detailed description would duplicate either what has been stated above in the diagnosis, or what is given below in the description of the type species. Species included here are:

*	<u>beuelensis</u>	Lange 1929, p. 49.
	<u>thaumasta</u>	Bogoslovskiy 1975, p. 308, pl. V, figs. 3,4, fig. 2, Kara-Zhar, Akt. Oblast'.

Remarks: Bogoslovskiy (1965) correctly stated that the type species was a clymeniid, rather than a <u>Tornoceras</u>, which had been thought hitherto. This he did using material from the southern Urals and Kazakhstan, for which he established a new genus, <u>Carinoclymenia</u>, distinguished from <u>Rectoclymenia</u> by the presence of a shallow ventral lobe. Another, equally diagnostic feature is the growth-line course. This, on the holotype of <u>beuelensis</u>, the type species (Pl. 5.32, Fig. 12), would be described as falcate. However, Bogoslovskiy's diagnosis (in translation, p. 992,3) states: "Growth striae form rounded lateral and broad, deep ventral sinuses", and "These form a deep broad angular ventral sinus, the two separated by an abruptly protruding rounded-angular (<u>sic</u>) projection situated almost in the middle of the lateral sides of the volution". The lack of the figure of the growth-line course, and the poor quality of the photographicillustrations means that these statements cannot be verified. At first sight Bogoslovskiy's description of the growth-lines and the one given here would seem to be incompatible. But the rather literal translation may not be quite correct, and, since Bogoslovskiy's identification of <u>beuelensis</u> was based solely on Müller's description (the original description of the holotype is brief and the illustration poor), which included a drawing of the growth-line course, clearly shown as biconvex, it must be concluded that any apparent differences are based on semantics rather than any real difference in the specimens. In any case use of the terms ventral and lateral areas, when the shell form is oxycone, are bound to lead to ambiguity and confusion.

Comparisons: Bogoslovskiy distinguished Carinoclymenia from Rectoclymenia by the presence of a shallow ventral lobe. While this feature has been used to distinguish other genera, e.g. Platyclymenia and Stenoclymenia, it does not seem to be particularly important, being more an artifact of the extremely compressed shell form, in contrast to the development of extra lobes without modification of shell form, which distinguishes Cheiloceras from Sporadoceras, Posttornoceras from Discoclymenia, and Uraloclymenia, Kiaclymenia and "Biloclymenia" (see Gen. Nov. C for a discussion of the correct usage of these names). However, the true Rectoclymenia (see above) has radial or weakly biconvex growth-lines (Pl. 5.31), which is a simpler way of distinguishing it from Carinoclymenia. Less clear cut is the dividing line between Carinoclymenia and species assigned here to Gen. Nov. F. These are all compressed, but their growth-lines show varying degrees of falcateness, and the ratio U/D ranges from 0.25-0.50, compared with only 0.10 in Carinoclymenia. The sutures of this group are largely unknown, and a more conservative interpretation would be to include them all as Carinoclymenia.

Acriclymenia Bogoslovskiy 1975, p. 306, was erected to contain the species thaumasta. It was distinguished from Carinoclymenia by faint longitudinal grooves near the venter, a broad ladle-shaped ventral growth-line sinus, and a suture with an unusually high ventral saddle. These characters seem too trivial to warrant separation at generic level.

Horizon and distribution: Known from the delphinus Zone of the southern Urals and Kazakhstan (USSR) and the annulata Zone of Thuringia, Oberfranken and the Sauerland (Germany).

Carinoclymenia beuelensis (Lange 1929)

Pl. 5.32, Figs. 1-12, Textfigs. 5.19J-L, 5.21

v* 1929 ?Tornoceras beuelensis sp. nov. - Lange, p. 49, pl. 1, fig. 4.
v 1956 Tornoceras beuelense Lange - Müller, p. 51, pl. 1, fig. 9, textfigs. 9,8.
1965 Carinoclymenia beuelensis (Lange) - Bogoslovskiy, p. 993, figs. 1a-d, 2a-b.

Type material: The holotype, an unnumbered specimen in the Museum für Naturkunde, collected by Lange from the annulata Zone at Beil, is illustrated here, Pl. 5.32, Figs. 11,12.
Material: Four specimens from the type locality (KW 2072, GT2021-3) have been examined as well as the specimen figured by Müller (1956).
Diagnosis: Carinoclymenia with oxyconic shell form, umbilical width amounting to 10% of the diameter, venter serrate, formed by the spinose projection of riblets, and bounded by very shallow depressions. Umbilical wall steep. Growth-lines falcate, periodically strengthened to form riblets at the venter, and weak ribs at the umbilical shoulder.

Description: The holotype (MfN, Pl. 5.32, Figs. 11,12) shows all the features mentioned in the diagnosis, especially the umbilical ribbing, which is more marked than in any of the other specimens described here. The whorl section, evolute to a diameter of ca 3mm, with a rounded venter (GT 2022, Pl. 5.32, Fig. 5) quickly becomes compressed, oxyconic (GT 2023, Textfig. 5.19L) with weakly convex, convergent flanks, and shallow depressions bounding the acute venter (KW 2070, Pl. 5.32, Fig. 3). Growth-lines are falcate at all diameters seen, with the apex of the larger salient maintaining a position approximately two-thirds of the way across the flanks from the umbilicus to the venter. Periodically they are strengthened and form lirae. Weak ribs in the umbilical region are already present by a diameter of 10mm. The serrate, spinose venter is clearly visible on GT 2021,3 (Pl. 5.32, Figs. 4,7). Wrinkle-layer is visible on KW 2070 (Pl. 5.32, Figs. 9,10); the dorsal wrinkle-layer consists of anastomosing striae running across the flank in a convex course, and the ventral wrinkle-layer is expressed as low bumps on the internal mould of the body chambers representing shallow pits on the inner surface of the body chamber shell. A normal clymeniid wrinkle-layer keel is formed along the ventral ridge, but here the striae are twice as frequent as on the flank.

The suture, observed only on Müller's rather damaged specimen (MfN, Pl. 5.32, Fig. 8), is shown in Textfig. 5.19J. It resembles Bogoslovskiy's description.

Dimensions:

	D	U	WW	WH
MfN, holotype	40	5	5	24
	24.2	3.9		13.4
KW 2070	46.8	3.9	6.6	26.3
	31.2	3.1	5.7	17.6
GT 2021	21.8	2.5		12.4
GT 2023	14.9	1.9	3.2	8.3
	8.9	1.5	2.4	5.0
	5.4	1.2	1.5	2.8
	3.4		1.15	1.5
			0.8	0.6

Horizon and distribution: The newly described topotypes were collected from an isolated outcrop at Beil and can be dated only as annulata Zone (see Chapter 7).

Family Clymeniidae Edwards 1849

Type genus: *Clymenia* Münster 1834.
Diagnosis: Member of the Clymeniaceae with a suture consisting of a broad ventral saddle; lateral lobe, usually asymmetrical with a shallow flank on the dorsad side and a deep U-shaped dorsal lobe.

Description: Shell subevolute to evolute with circular or compressed whorl section. Growth-lines convex, concavo-convex or weakly to strongly biconvex, with a ventral sinus. Ribbing may be present. The suture is described above. Genera are distinguished by the shape of the lateral lobe, and those currently assigned to this family are *Aktuboclymenia* Bogoslovskiy 1979b, *Protoxyclymenia* Schindewolf 1923a, *Clymenia* Münster 1834, and *Kosmoclymenia* Schindewolf 1949a.

Discussion: A relationship between the three last named genera has long been recognised. Schindewolf arranged them into the morphological series *Clymenia* - *Protoxyclymenia* - *Kosmoclymenia*, showing a progressive sharpening of the lateral lobe, but this theory could not be substantiated by stratigraphic findings. Lange (1929) reported *Protoxyclymenia* and *Kosmoclymenia* from the *delphinus* Zone, yet *Clymenia* first appears above, in the *Clymenia* Stufe.

Recently Bogoslovskiy (1979b) has erected a new genus *Aktuboclymenia*, known from the *Platyclymenia* Stufe. It is characterised by a very shallow, but slightly asymmetrical lateral lobe. This he regarded as the initial genus in the evolutionary series *Aktuboclymenia* - *Protoxyclymenia* - *Kosmoclymenia*, with *Clymenia* being a short-lived off-shoot during the early *Clymenia* Stufe (Textfig. 4.13).

Schindewolf (1957, 1972) and Korn (1981a) would regard the small, highly ribbed genera Sulcoclymenia, Piriclymenia and Ornatoclymenia as belonging to this family. To insert them here would, however, make this family polyphyletic since it has been argued (Schindewolf 1972) that Sulcoclymenia is descended from Platyclymenia, yet the same is true for Aktuboclymenia, included here in the Clymeniidae. Therefore the group Sulcoclymenia, Piriclymenia and (?) Ornatoclymenia may also deserve familial status. A conservative approach is adopted here, and the group is included as a new subfamily within the Platyclymeniidae. Schindewolf would also include Trochoclymenia Schindewolf 1926 in the Clymeniidae. This has an umbilical lobe lying outside the seam, a narrow ventral saddle, lacking shallow ventro-lateral lobes, and the steeper flank of the lateral lobe is the dorsad one, unlike the other four genera included in the Clymeniidae (see Chapter 4).

Horizon: The family ranges from the delphinus Zone to the evoluta Zone.

Genus Clymenia Münster 1834

Textfig. 5.23

non	1801	Planulites gen. nov. - Lamarck, p. 101.
non	1822	Planulites - Parkinson, p. 163.
	1831	Planulites - Münster, p. 182.
p	1832	Planulites Parkinson - Münster, p. 4.
p	1834b	Clymenia Münster - Münster, p. 66.
non	1838	Endosiphonites gen. nov. - Ansted, p. 416.
p	1863	Clymenia Münster - Gümbel, p. 35.
p	1884	Oxyclymenia gen. nov. - Hyatt, p. 313.
p	1902	Clymenia Münster - Frech, p. 29.
p	1908	Orthoclymenia gen. nov. - Wedekind, p. 605, 619.

	1914	Laevigites gen. nov. - Wedekind, p. 47
	1923a	Laevigites Wedekind - Schindewolf, p. 464.
p	1924	Cyrtoclymenia Hyatt - Schmidt, p. 129.
	1929	Orthoclymenia Wedekind - Lange, p. 116.
non	1937a	Clymenia Münster - Schindewolf (= Cymaclymenia).
	1957	Clymenia Münster - Schindewolf, p. L44.
	1960	Clymenia Münster - Bogoslovskiy, pl. XXXII, fig. 3.
	1966	Clymenia Münster - Chlupàč, p. 54.
	1981	Clymenia Münster - Ruan, p. 121

Type species: Planulites laevigatus Münster, by subsequent designation of Frech 1902, p. 29, (and 1913, p. 5).
Diagnosis: Member of the Clymeniidae with serpenticonic shell, very faint convex-concave or biconvex growth-lines, with a suture consisting of a ventral saddle, an asymmetric lateral lobe, and a deep pointed dorsal lobe.

Description: Serpenticonic shell with wide shallow umbilicus, usually greater than 50% of the diameter, circular to compressed whorl section and narrow, shallow impressed area. The shell surface is almost smooth. Growth-lines are very faint, radial or rursiradiate, with a very shallow flank sinus, and a shallow mid-ventral sinus. Spiral ornament is known, as are faint plicate ribs, ribs, and deep constrictions on the body chamber. The suture consists of a ventral saddle, a broad concave, asymmetric lateral lobe, which has a steeper ventrad side, and a deep dorsal lobe.

Available specific names: The following specific names have been used in genus Clymenia sensu stricto.

*laevigata	Münster 1831, p. 182; 1832, p. 5, pl. I, figs. 1a-f, Schübelhammer, Oberfranken, known also from Czechoslovakia, Rheinische Schiefergebirge, England, Carnic Alps, Montagne Noire, N. Africa, W. Australia, s.w. China.
cingulata	Gümbel 1863, p. 137, pl. XVI, figs. 9a-d, Schübelhammer, Oberfranken.

cranoides	Lange 1929, p. 118, pl. 3, fig. 34a, fig. 34 Melschede (= Hövel), Sauerland.
cranoideformis	Kolotukhina 1938, p. 675, pl. 2, fig. 10, Karagandinskaya Oblast', USSR.
h elliptica	Münster 1839, p. 7; Gümbel, 1863, p. 137, pl. XVI, fig. 7, Schübelhammer, Oberfranken.
hoevelensis	Wedekind 1914, p. 41, pl. IV, figs. 1,2, Hövel, Sauerland.
nana	Münster 1839, p. 7; Gümbel 1863, p. 137, pl. XVI, fig. 8, Heinersreuth, Oberfranken.
pygmea	Münster 1832, p. 6, pl. 1, figs. 2a-d, Geigen and Schübelhammer, Oberfranken.
rumala	Ruan 1981, p. 122, pl. 29, figs. 32-8, pl. 31, fig. 17, textfig. 89, s.w. China.
semicingulata	Münster 1839, p. 7; Gümbel 1863, p. 137, pl. XVI, fig. 5, Schübelhammer, Oberfranken.
semiplicata	Münster 1839, p. 7; Gümbel 1863, p. 137, pl. XVI, fig. 6, Schübelhammer, Oberfranken.
h speciosa	Münster 1839, p. 7; Gattendorf, Oberfranken.
spiratissima	Schindewolf 1923a, p. 465, pl. XVIII, fig. 4, Kirch-Gattendorf, Oberfranken, Sauerland.
striatula	Lange 1929, p. 119, pl. 31, fig. 35, Burg, Rösenbeck, Sauerland.

The Münster species may all be synonyms of Cl. laevigata, and are discussed with that species below, with the exception of Cl. nana, for which no type material has been traced. Other authors seem to have used this genus as a repository for evolute specimens which they could not place elsewhere. Clymenia rumala Ruan is the best documented species. It has a certain Clymenia suture, subevolute coiling, and weakly rursiradiate biconvex growth-lines. Clymenia cranoides (Lange) known from two specimens, supposedly from the upper Clymenia Stufe at Hövel has a Clymenia suture, subevolute coiling (U/D=0.4, D=21), and a compressed whorl section. Growth-lines were slightly rursiradiate and linear. Clymenia striatula (Lange) has weak ribs, and is discussed under Cl. laevigata. Clymenia spiratissima (Schindewolf) is discussed under Cl. spiratissima, below. No suture is known from Cl. cinqulata Gümbel, but it is described below. Clymenia cranoideformis (Kolotukhina) was described as having Clymenia type suture, but the illustration (fig. 12) does not confirm this. No growth-lines were preserved. Described from small specimens this species could easily belong to Protoxyclymenia or Cyrtoclymenia.

Discussion: The nomenclature of this genus was (and still is) in a "confused state" (Schindewolf 1949a, p, 64). Schindewolf had at least four attempts at clarifying the problem (1937a, p. 13; 1949a, p. 65; 1955, p. 418, and 1972, p. 23). Further comments were made by Turner (1962, p. 183). It is still questionable whether a correct decision has been arrived at.

There are three questions to answer; whether Clymenia is a valid genus, if so, when it was first used, and what is to be regarded as its type species?

The name Clymenia was first used in the Neues Jahrbuch (Münster 1834a, p. 42,3), where Münster states in a letter dated 1st December 1833 that his publication "Über Planuliten und Goniatiten ..." (Münster 1832) will shortly be translated into French, and that in it he intends to replace the generic name Planulites Parkinson with Clymenia. No reason was given for this change of name.

It seems worthwhile, at this stage, to document the various descriptions of Planulites. The earliest post-Linnaean usage is by Lamarck (1801, p. 101) who, under the section "Mollusques, Cephales, Ammonitier" states,

> Planulite Planulites. Coq. en spirale discoide, a tours contigus et tous apparens, et ayant les parois simples. Cloisons transverses entières. Planorbiter ....* Planulites sulcata n. Corne - d'ammon à raies andoyantes? Bourg. Petrif. t. 46, f. 290.

Bourget (1742) illustrated in pl. 46, fig. 290, a serpenticonic shell which has convexo-concave growth-lines. I could find no description in the accompanying text, but Lamarck seems to have interpreted it as a cephalopod with simple sutures.

Parkinson (1822, p. 163) to whom Münster (1831, 1832) refers, has a more precise definition, but since this lacks an illustration it is also difficult to interpret,

> A multilocular, spiral, flattish and discoidal shell; the turns contiguous and apparent, the chambers separated by plain septa pierced with a marginal siphuncle. Fossil. As the shells of the preceding genus (*Orbulites*) have possessed the outer appearance of Nautilus, with the internal characters of ammonites, so this shell possesses the external appearance of *Ammonites*, and, at the same time, is characterised by the plain concave septa of *Nautilus*. As its external form agrees with that of the following genus (*Ammonites*), another figure is not requisite.

The type species of *Planulites* would seem to be *Pl. sulcata* Lamarck, illustrated by specific reference to Bourget's earlier illustration. This figure is virtually uninterpretable and could be of a cephalopod, a gastropod or an annelid. I have been unable to trace a modern usage of the name *Planulites*. Clearly Lamarck intended it as a cephalopod, but without a more precise diagnosis, or an unambiguous figure it must remain a *nomen nudum*. Parkinson (1822) gave a similarly unhelpful account, which did not serve to clarify the identity of *Planulites*. The relationship surrounding the various usages of *Clymenia* and *Planulites* runs as follows: *Clymenia* Münster 1834 = *Planulites* Münster 1831, 1832; *Planulites* Münster ≠ *Planulites* Parkinson or *Planulites* Lamarck.

The name *Clymenia* was derived from Clymene, daughter of Oceanus, but this name had already been used (by Oken 1807, _fide_ Neave 1939, p. 770). The French translation of Münster 1832 appeared in August 1834, entitled "_Memoire sur les Clymènes et les Goniatites du calcaire transition du Fichtelgebirge_", in which _Clymenia_ is used instead of _Planulites_. Therefore, _Clymenia_ should date from 1834. Previously Schindewolf (1937a) argued that its first usage had been in 1832 in Goldfuss' Naturhistorischen Atlas Lief. 4 (1832, p. 489, and Atlas pl. 439, fig. 7) where _Cl. striata_ was described. However, he later (1955) showed that this particular part was published long after, in 1844. Also there is a catalogue of fossils in Münster's Collection (Münster 1833) in which the name _Planulites_ is still used, which also suggests that _Clymenia_ was not adopted in 1832.

Other red herrings in this account are the generic names, _Clymenites_ and _Clymenea_. _Clymenites_ was used by Münster in 1835 in another letter to the _Neues Jahrbuch_ (1835, p. 334), but without qualification or description. According to the _Code_ (Art. 56b) this must fall as a homonym of _Clymenia_. Presumably it represents an attempt to bring the ending of this new ammonoid generic name into line with _Ammonites_, _Goniatites_ and _Ceratites_. Four Nomenclators (details in Schindewolf 1949a) list the genus _Clymenea_. The earliest reference is in Scudder 1882, p. 78 (Nomen. Zool. Suppl. list p. 28 and Univ. Index p. 72), derived from "Agassiz". Scudder cites here Münster 1830, which is a work entitled "_Bemerkungen zur näheren kenntnis der Belemniten_". Neither Schindewolf (1937a, p. 14; 1949a, p. 65), nor Cox (Opinion 182), nor I can find such a reference, so this must be presumed to be an error, copied uncorrected by subsequent compilers of nomenclators.

A type species for _Clymenia_ was first proposed explicitly by Frech (1913, p. 5) "_Clymenia_ s. str. Typus: _Clymenia laevigata_

Münster", though he had earlier stated (1902, p. 29) "Bei der ersten Beschreibung von Clymenia (1839) hat Graf Münster die 1832 als Planulites bezeichnete Clymenia laevigata als typus der Gattung vorangestellt". Schindewolf (1957, p. L54) accepted the earlier of these statements as a valid type designation "Clymenia Münster ....(Planulites laevigitus Münster 1832; SD Frech 1902)". Therefore, in the absence of any designation by a previous author Frech (1902) is considered to have established Pl. laevigatus as the type species of Clymenia.

Orthoclymenia Wedekind 1908 and Laevigites Wedekind 1914, established without type species, both contained laevigata Münster, then already established as the type species of Clymenia, and so are both junior objective synonyms of Clymenia.

Comparisons: The most similar genus to Clymenia is Aktuboclymenia, from which it was descended. Aktuboclymenia differs only in being subevolute, and having concavo-convex growth-lines, Protoxyclymenia has a much weaker adventive lobe, and different growth-lines.

Horizon and distribution: Clymenia is known from the middle Clymenia Stufe of England, Rheinische Schiefergebirge, Poland, s. Urals, Montagne Noire, N. Africa, and W. Australia.

Clymenia laevigata (Münster 1831)

Pl. 5.18, Figs. 5-10,13,14, Pl. 5.20, Figs. 2,8,9,12,13

Textfigs. 5.22A,C, 23

* 1831 Planulites laevigatus sp. nov. - Münster p. 182,

1832 Planulites laevigatus Münster - Münster, p. 5, pl. I, figs. 1a-f.

1834b Clymenia laevigata Münster - Münster, p. 67, pl.I, figs.1a-f

1839 Clymenia laevigata Münster - Münster, p. 3,35, pl. Ia, figs. 1a-f.

1853a Clymenia laevigata Münster - Sandberger, p. 184, pl. VII, figs. 1a-f.

1863 Clymenia laevigata Münster - Gümbel, p. 137, pl. XVI, figs. 5a-g, 6a,b, 7a-c, only.

1902 Clymenia laevigata Münster - Frech, pl. V(IV), fig. 2.

1914 Laevigites laevigatus Münster - Wedekind, p. 48, pl. IV, figs. 1,2.

1914 Laevigites hoevelensis Münster - Wedekind, p. 49, pl. IV, fig. 3.

v 1923a Laevigites laevigatus Münster - Schindewolf, p. 464.

v Laevigites hoevelensis Münster - Schindewolf, p. 463, pl. XVIII, fig. 3.

1924 Cyrtoclymenia laevigata Münster - Schmidt, p. 129, textfig. 4.

1929 Orthoclymenia laevigata Münster - Lange, p. 117.

1950 Clymenia laevigata Münster - Termier and Termier, p. 74, pl. CLIX, fig. 25.

1957 Clymenia laevigata Münster - Schindewolf, p. 144, figs. 41.4.

1960 Clymenia laevigata Münster - Bogoslovskiy, pl. XXXII, fig. 3.

1966 Clymenia laevigata Münster - Chlupàč, p. 94, pl. II, figs. 1-3, pl. III, figs. 1-4, pl. IV, fig. 4.

? 1975 Clymenia cf. laevigata Münster - Petersen, p. 46, pl. 1, fig. 5, textfig. 25.

1981 Clymenia laevigata Münster - Ruan, p. 121, pl. 29, figs. 22-24, textfig. 88.

Type material: SM H10366 (Münster Collection), illustrated in Pl. 5.18, Figs. 7,8, Textfig. 5.22B,C, collected from Schübelhammer, Oberfranken, is proposed as the lectotype, and BSP AS VII 605 (Pl. 5.18, Figs. 13,14) is proposed as the paralectotype.

Remarks: The type series (Münster 1833) contained at least nine specimens. Münster (1832) figured at least two specimens; one attaining a diameter of ca 140mm, and the other a fragment, cut to show the whorl section. This latter specimen (BSP AS VII 603; Pl. 5.18, Figs. 11,12) has been located, but since it shows rursiradiate ribs, is excluded from this species. The large specimen illustrated by Münster cannot now be identified. Grouped together in Munich in September 1978 were some nine specimens, associated with various Münster and Gümbel labels relating to laevigata and its varieties. More specimens in Münster Collections labelled as laevigata and varieties from Schübelhammer were located in Cambridge (SM H10363-72, 10398-00), London (BM 81849, C83295, 81828, C82838), and Berlin (11 unnumbered specimens). Of these two, well preserved and resembling the original figure (Münster 1832, pl. I, figs. 1a-c), were selected as types. Some of the others are described below, too.

Diagnosis: Large Clymenia, commonly attaining a diameter of 200mm. The whorl section is circular until a diameter of ca 60mm, then becomes increasingly compressed; U/D increases from 0.48 to 0.55 between diameters of 20 and 200mm. Growth-lines are barely visible, rursiradiate, biconvex, with the dorsad salient occupying half of the flank with a shallow sinus over the venter. Secondary ornament is restricted to faint plications, running parallel with the growth-lines.

Description: The lectotype (Pl. 5.18, Figs. 7,8) is very well preserved. The whorl section (Textfig. 5.22A,C) is circular up to a diameter of ca 40mm (R = 24), becoming increasingly compressed thereafter, with flanks converging on a narrow venter. Flanks are quite flattened in examples (e.g. SM H10363) larger than the lectotype. The ratio U/D varies between 0.55 and 0.45, between diameters of 25 and 80mm. At all diameters the impressed areas are small, only 10-12% of the previous whorl is enveloped. Growth-lines are extremely difficult to see on the lectotype; until a diameter of ca 40mm they are slightly rursiradiate and weakly biconvex. Thereafter their course is more radial, and the flank sinus even less developed. On the body chamber there are a series of weak ventral grooves numbering 20 in the last half whorl preserved running parallel with the growth-lines, which are reflected on the internal mould as constrictions. Spiral lines run around the venter. The external suture (Textfig. 5.22B) comprises a broad flat ventral saddle, and an asymmetric lateral lobe.

In excess of 100 specimens from Oberfranken, together with many from the Rheinische Schiefergebirge, have been examined, which makes this the commonest species in collections of clymeniids. This wealth of material lacks any precise stratigraphic details, and so makes interpretation of variation within the species impossible to define. A number of specimens has been selected for further comment.

The proposed paralectotype, BSP AS VII 605 (Pl. 5.18, Figs. 13,14) is a large specimen attaining a diameter of ca 130mm. This is almost the same size as that of Münster's figure (1832, pl. I, fig. 1a), but there are major differences in the appearance of the two specimens. This is why it is not proposed as the lectotype. It shows growth-lines which are more rursiradiate than on the lectotype, visible until a diameter of 80mm. A spiral ornament runs around the venter. An unnumbered specimen in Munich (Pl. 5.18, Figs. 5,6) also shows growth-lines which are more rursiradiate than the lectotype and they have an almost concave course on the body chamber. The label associated with this specimen suggests that it is the "original" of Münster's _Cl_. _laevigata_ var. _semiplicata_. BSP AS VII 601 (Pl. 5.18, Figs. 9,10), figured by Gümbel (1863, pl. XVI, figs. 7a,b) as the "original" of Münster's _Cl_. _laevigata_ var. _elliptica_, has a deep annular constriction at a diameter of 40mm. No trace of growth-lines remains. SM H10365 (Pl. 5.20, Figs. 12,13) and BM C82328 (Pl. 5.20, Fig. 2) do not appear to differ from the lectotype. SM H10362 has 16 septa in the last whorl, up to a diameter of 105mm.

Dimensions:

	D	U	WW	WH	R
SM H10366, lectotype	82.5	42.9	16.9	22.7	47.3
	64,6	33.2	14.1	17.3	-
			13.8	17.1	34.7
			8.2	9.8	18.2
			4.7	ca 5.5	10.9
			2.5	2.8	5.5
BSP AS VII 605 paralectotype	120	64.2	21.0	32.5	67.2
BSP AS VII 601	45.3	24	10.2	12.7	26.3
BSP, Pl. 5.18, Figs. 5,6	65.5	33.3	15.4	19.2	38.1
SM H10365	43.5	22.2	11.5	12.8	ca26
SM H10368	45.7	23.3	12.7	13.8	26.6
HU P82.22	185	ca100	26	46	

Discussion: Münster's original description (1831, p. 182) runs,

> Parmi plusiers espèces de Nautiles du Fichtelgebirge, le plus commun est notre Planulites laevigatus, N. sp., je l'ai trouvé varient d'un demi-pouce à sept pouces en diametre, le test epais est tout à fait lisse et a huit tours de spire completement visible et se retrécissant insensiblement.

House (in Turner 1962) considered this to be a "brief but legally adequate description", with which I would agree. There is no other large, evolute smooth shelled ammonoid from the Fichtelgebirge known to me, with which laevigata could be confused. Schindewolf (1972, p. 75) disagreed with House on the grounds that the description was vague and ambiguous, and considered Planulites laevigatus Münster 1831 to be a nomen nudum. He did not quote all of Münster's description but paraphrased it, so as to make it seem less precise, and suit his own argument.

Turner believed that because Clymenia Münster 1834 was a replacement name for Planulites Münster non Parkinson, laevigata should become its type, by monotypy, being the only species mentioned in the earliest reference to *Planulites sensu* Münster. Schindewolf's counter to this was that Münster (1831, p. 228) also mentioned the species *undulatus*. This, however, is a true *nomen nudum*, being simply a reference to the name, but also this reference occurs in a separate article from that in which *laevigata* appears. Turner's argument is appealing but invalid. The rules (*Code*, Art. 68(c)) state "Monotypy - A genus originally established with a simple nominal species as its type,...(type by monotypy)". When "originally established" (Münster 1834a) *Clymenia*, replacing *Planulites* Münster, had at least 15 included species.

Münster (1839) introduced names for several briefly described varieties of *Cl. laevigata*; none was illustrated:

elliptica	"an elliptical shape in young and old"
nana	"up to 1" in diameter"
semicingulata	"ring-like ribs on the round venter"
semiplicata	"half-ribs on the inner whorls"
speciosa	"wide (= high) whorls, over 1" in diameter"

Gümbel (1863, pl. XVI) figured what he considered to be Münster's originals of *laevigata* (fig. 5a-c), *semiplicata* (fig. 6) and *elliptica* (fig. 7). Only that of *Cl. elliptica* can be identified with certainty; it (BSP AS VII 601) is considered to be a *Cl. laevigata*. It does not have a whorl section which is more elliptical than *Cl. laevigata* (Pl. 5.18, Figs. 9.10).

The specimen Gümbel (1863, pl. XVI, fig. 5) figured as *laevigata* cannot be traced. That figured as *semiplicata* has already been discussed. Two more specimens were given Münster names, but were not attributed as originals: *Cl. laevigata* var. *semicingulata*, illustrated (1863, pl. XVI, fig. 5e) by a small fragment of body chamber showing weak ribs, and *Cl. laevigata* var. *nana* (1863, pl. XVI, fig. 8), neither can be traced. *Clymenia* *nana* is dicussed with *Cl*. sp. *a* below. *Cl*. *semicingulata* cannot be interpreted from the figure.

Lange (1929) also named a species with radial ribs, *Cl*. *striatula*. He recorded two specimens with the same shell form, one showed the suture, and the other a ribbed ornament. The extent of the impressed area (one third of the height of the previous whorl) would seem to distinguish this species from Münster's ribbed varieties.

Wedekind (1914) and subsequently Schindewolf (1923a) recognised two major species of *Clymenia*; *Cl*. *laevigata* and *Cl*. *hoevelensis* (Wedekind), distinguished by their sutures. It was stated (Wedekind 1914) that in *Cl*. *hoevelensis* the lateral lobe ran smoothly into the ventral saddle, whereas in *Cl*. *laevigata* there was a sharp knick separating the two. Wedekind's interpretation of *Cl*. *laevigata* in this way rests on Gümbel's figure (1863, pl. XVI, fig. 5c) of Münster's "original". It has already been suggestedthat this is not Munster's original, and the proposed lectotype has a suture which is like Münster's illustration (1832, pl. VI, fig. 1c) and *Cl*. *hoevelensis* (Wedekind), which means that the two species are synonyms. Lange (1929) after collecting 140 specimens, believed that the apparent difference between *Cl*. *hoevelensis* and *Cl*. *laevigata* was caused by removal of material during preparation.

Horizon and distribution: As for the genus.

Clymenia spiratissima (Schindewolf 1923a)

Pl. 5.18, Figs. 2-4, Pl. 5.20, Fig. 1, Textfig. 5.23

(?) 1832 *Planulites pygmeus* sp. nov. - Münster, p. 6, pl. I, figs. 2a-d.

? 1863 Clymenia laevigata var. nana Münster - Gümbel, pl. XVI, fig. 8.

* 1923a Laevigites spiratissimus sp. nov. - Schindewolf, p. 465, pl. XVIII, fig. 4.

? 1929 Orthoclymenia spiratissima Schindewolf - Lange, p. 118,

Type material: No type has been designated. The specimen figured by Schindewolf (1923a) cannot now be traced at Erlangen, its stated repository.

Diagnosis: According to Schindewolf (1923a) this species could be distinguished from Cl. laevigata by its more slowly increasing whorl height, and more evolute shell coiling (see Textfig. 5.23). No actual measurements were given with the original description, only ratios.

Description: A description can be produced only by looking at Schindewolf's illustration. This shows an evolute, weathered shell with no ornament preserved. If the illustration is at natural size then at a diameter of 37mm the ratio U/D is 0.65 and WH/D is 0.22. The whorl section is quadrate with flattened flanks and venter. Measurements from a number of specimens are plotted on Textfig. 5.23: the ratio U/D declines from 0.67 at a diameter of 10mm, to 0.57 at a diameter of 50mm. WW/WH has been calculated at only four diameters but the slope on the regression line is shallower than that for laevigata. Whorl height itself seems to increase more rapidly than Cl. laevigata (contra Schindewolf 1923a). Schindewolf described the suture as like that of L. hoevelense (= Cl. laevigata).

Dimensions:

	D	U	WW	WH
Schindewolf 1923a	47	28		12.5
pl.XVII, fig.4,	37	24		8
lectotype.				

	D	U	WW	WH
BM C83292	18.1	11.9		3.8
SM H7537	9.7	6.5	2.16	1.8

Discussion: The lack of a type specimen makes diagnosis of this species difficult. Schindewolf (1923a, p. 467) stated that he had collected many small examples from Beds 16 and 17 at Kirch-Gattendorf, yet the specimen he illustrated was relatively large (D = ca 50), and from a museum collection. It is possible, therefore, that most of the material he used to describe the species differed from the illustrated examples.

Lange (1929) mentioned the species and gave comparative measurements to discriminate it from _Cl_. _laevigata_. He found only two specimens, yet from the same levels he collected 140 examples of _Cl_. _laevigata_, with no forms intermediate in morphology between the two species.

I have observed numerous small (D < 20) evolute specimens which fit Schindewolf's description of _Cl_. _spiratissima_, including some 50 collected and labelled by him from Ballberg, Hövel, now housed in the Museum für Naturkunde, Berlin. Two are illustrated here: MfN, labelled as _Cl_. _pygmea_ Münster Collection, Schübelhammer, (Pl. 5.18, Fig. 2); and BM C83292 Münster Collection, Schübelhammer (Pl. 5.20, Fig. 1). C83292 shows faint traces of rursiradiate, convexo-concave growth-lines at a diameter of 18mm and the Berlin specimen has deep rursiradiate constrictions on the last half whorl. Both specimens appear to have quadrate whorl sections. A small specimen from Erlangen-Nürnberg (Pl. 5.18, Figs. 3,4) may represent the inner whorls of this species, and clearly shows the protoconch.

Planulites _pygmeus_ Münster is illustrated (1832, pl. I, fig. 2) as small, with rursiradiate growth-lines, and a _Clymenia_ type suture, and could be regarded as a senior synonym of Cl. spiratissima. However, the figured specimen cannot be traced, and the specimen which Gümbel illustrated (1863, pl. XVII, fig. 7; BSP) as Münster's original is a Kosmoclymenia. There are four specimens in Cambridge labelled as Cl. pygmea; one (H7540) is a Kosmoclymenia, and one (H7538) is like the two specimens attributed here to Cl. spiratissima. The other two (H7537, 7539) are too small to be identified. Only SM H7540 shows trace of growth-lines or suture. Therefore, Cl. pygmeus Münster is treated as a nomen dubium.

Clymenia laevigata var. nana Münster, described (1839, p. 7) as "not exceeding an inch in diameter", could on that information alone, be indistinguishable from Cl. spiratissima. Gümbel (1863, pl. XVI, fig. 8) illustrated Münster's original of Cl. nana, but did not describe it. Schindewolf (1923a) stated that Cl. spiratissima and Cl. nana could be distinguished by the more rounded whorl section, and more rapid increase in whorl height in the latter.

Comparisons: The graphs in Textfig. 5.23 show how the parameters U, WW and WH, and the ratios U/D and WW/WH can be used to distinguish between Cl. laevigata and Cl. spiratissima. Maximum diameter is another criterion. Dimorphism is not a likely explanation for this difference; the species do not co-occur, and their whorl form and coiling are different at all stages.

I have found only one specimen (SM H10364, Pl. 5.20, Figs. 10,11, Textfigs. 5.22,23) which cannot be easily assigned to either Cl. spiratissima or Cl. laevigata. This has whorls which initially increase in height more rapidly than Cl. laevigata, and have a more compressed whorl section, being oval by a diameter of 10mm (16mm in Cl. laevigata). Growth curves for this specimen are closer to Cl. spiratissima than Cl. laevigata, hence it is named Clymenia aff. spiratissima.

Horizon and distribution: This species is known from the ?lower Clymenia Stufe (fide Schindewolf 1923a) of the Rheinische Schiefergebirge, Oberfranken and the Carnic Alps.

? Clymenia cingulata Gümbel 1863

Pl. 5.18, Fig. 1, Textfig. 5.23

* 1863 Clymenia laevigata var. cingulata Gümbel, p. 137, pl. XVI, figs. 9a-c.
v 1923a Laevigites cingulatus Braun (MS) - Schindewolf, p. 464, pl. XVIII, fig. 5.

Type material: No type material has been traced, but, because the nature of the species is not in contention, no neotype need be proposed.

Diagnosis: Species of ?Clymenia with strong widely spaced annular ribs on the inner whorls.

Description: Only one specimen has been seen. This (MfN; Pl. 5.18, Fig. 1), from Braunau, Wildungen, was illustrated by Schindewolf (1923a, pl. XVIII, fig. 5). Coiling is evolute U/D = 0.51 at a diameter of 17mm. The whorl section is quadrate, with flattened venter and flanks. Early whorls are smooth, the first ribs appear at a diameter of 5mm, and thereafter there are six per whorl. The ribs and growth-lines are weakly prorsiradiate and concave over the flanks. Ribs continue over the ventrolateral shoulder onto the margin of the venter. No suture has been observed.

Dimensions:

	D	U	WW	WH
MfN, Pl. 5.18, Fig.1	17	8.1	-	4.9

Discussion: Schindewolf (1923a) stated that the suture of this species was the same as Laevigites hoevelense, and so it is included here in Clymenia. Doubt arises, however, because no other Clymenia has concave growth-lines, a character which normally distinguishes Platyclymenia.

Horizon and distribution: Schindewolf (1923a) stated that this species was collected together with Cl. laevigata at Gattendorf, which he interpreted as indicating the lower Clymenia Stufe. It is also known from Wildungen, Kellerwald, and the Carnic Alps.

Genus Protoxyclymenia Schindewolf 1923a

Textfig. 5.25

	1923a	Protoxyclymenia gen. nov. - Schindewolf, p. 433.
p		Oxyclymenia Gümbel - Schindewolf, p. 467.
	1923b	Protoxyclymenia gen. nov. - Schindewolf, p. 28, 63.
	1929	Protoxyclymenia Schindewolf - Lange, p. 120.
	1938	Protoxyclymenia Schindewolf - Kolotukhina, p. 683.
	1965	Protoxyclymenia Schindewolf - Sun and Shen, p. 51.
	1966	Protoxyclymenia Schindewolf - Chlupáč, p. 95.
	1975	Protoxyclymenia Schindewolf - Petersen, p. 48.

Type species: Clymenia dunkeri Münster 1839, by original designation.

Diagnosis: Member of the Clymeniidae with weakly biconvex growth-lines and a suture consisting of a dorsal saddle with very shallow ventro-lateral lobes on either side, asymmetrical rounded lateral lobe with the shallower slope dorsad, and a deep U-shaped dorsal lobe.

Description: An assessment, and hence description, of the genus is difficult because few well preserved specimens have been studied or reported. Most of the specimens known to me are discussed below under the type species Pro. dunkeri (Münster 1839); the only other known species is Pro. serpentina (Münster 1832), formerly thought to be a Kosmoclymenia.

Discussion: The two species assigned to this genus have such differing growth-lines that they could be placed in separate genera (cf. the groups into which Kosmoclymenia is divided, below). However, such a formal step is unnecessary in this thesis, and they are described simply as Protoxyclymenia.

Horizon and distribution: Known from the ?annulata Zone of Oberfranken, and the lower part of the Clymenia Stufe of Sauerland, Oberfranken and the southern Urals.

Protoxyclymenia dunkeri (Münster 1839)

Pl. 5.28, Figs. 1,4,5, Textfig. 5.24H-K

v*	1839	Clymenia dunkeri sp. nov. - Münster, p. 15, pl. XVI, figs. 1a,b.
	1843	Clymenia dunkeri Münster - Münster, p. 42, pl. XVI, figs. 1a,b (copy of Münster 1839).
vp	1863	Clymenia dunkeri Münster - Gümbel, p. 135, pl. XVI, figs. 3a-c, non figs. 4a-c.
non	1902	Clymenia dunkeri Münster - Frech, p. 29,31, textfigs. $1a_{1-5}$.
	1923a	Protoxyclymenia dunkeri Münster - Schindewolf, p. 433.
?	1965	Protoxyclymenia dunkeri Münster - Sun and Shen, p. 51, pl. II, fig. 5, textfig. 9.

Type material: BSP AS VII 559 from Gattendorf, Oberfranken, is proposed as the lectotype.

Remarks: The type series consisted of the three specimens from Schübelhammer, Heinersreuth and Gattendorf. The specimens figured by Münster were recorded as from Verneuil's Collection and have not been traced. The lectotype was figured by Gümbel (1863) as "Münster's original".

Diagnosis: Protoxyclymenia with prorsiradiate growth-lines and weakly developed, slightly biconvex ribs on the body chamber.

Description: The poorly preserved nature of the lectotype and the absence of any well preserved comparative material from the type locality makes an accurate description difficult.

The lectotype, illustrated in Pl. 5.28, Fig. 1 and Textfig. 5.24K, attains a maximum diameter of approximately 35mm, where the ratio U/D is 0.37. Early whorls appear circular in section and evolute, with the whorl section becoming compressed and the flanks flattened and parallel in the last whorl, after a diameter of ca 17mm. The venter appears tabulate on the body chamber. Growth-lines are preserved only on the inner whorls up to a diameter of ca 15mm. Here they are radial and straight and expressed as raised lirae. There are faint indications of ribs caused by bunching of growth-lines at a diameter of ca 12mm. Twelve poorly preserved faintly biconvex ribs are visible on the last quarter whorl of the body chamber.

The suture, visible at a whorl height of 5.5mm, has been polished and thus damaged, and the ventrad half has been dissolved away. The remaining half of the lateral lobe is illustrated in Textfig. 5.24K and really only shows that this species has a lateral lobe.

However, a more detailed description can be provided by using a single specimen from Wäschholz (Pl. 5.28, Figs. 4,5, Textfigs. 5.24H-J) on which growth-lines and the suture are visible. The shell form is evolute, with a compressed oval whorl section and a narrow tabulate venter (Textfig. 5.24J). Growth-lines are prorsiradiate, weakly biconvex with a prominent ventro-lateral salient (Textfig. 5.24H). Weak ribs, caused by bunching together of 6 or 7 growth-lines, are formed at the umbilicus. Growth-lines over the ventral band are out numbered 6:1 by the flank growth-lines. The formation of a ventral sinus coincides with the formation of the groups of bunched growth-lines. The external suture, consisting of a shallow asymmetric lateral lobe, and a flat ventral saddle, is illustrated in Textfig. 5.24I.

Dimensions:

	D	U	WW	WH
Lectotype, Pl.5.28 Fig.1, BSP AS VII 559.	32	13.9		11.8
81D 6403.2, Pl.5. 28, Figs.4,5.	ca20		5.1	6.9
Pl.5.28, Figs.14, 15.	23.8	9.1	7.0	8.2
Pl.5.28, Figs.8,9, 12,13.	22.5	9	6.9	7.3
Lange, 1929, p.120	28.0	10.5	ca8.7	10
Sun and Shen, 1965, p.52.	53.6	29.3	10.3	15.5
Measured from Chlupàč, 1966, fig. 3b.			7.0	12.0

Discussion: The two specimens figured by Gümbel (1863) as Cl. dunkeri remain in Munich. One, the lectotype, has already been described and the other (BSP AS VII 558, Pl. 5.28, Fig. 3, figured by Gümbel 1863, pl. XVI, fig. 4), from Geuser, is proposed as the lectotype of Cl. sedgwickii Münster 1840, and is described below as a Pseudoclymenia. Two further specimens from Geuser are preserved at Cambridge and one at least (SM H10384) is a juvenile Pseudoclymenia. The other (SM H10383), a fragment, is not identifiable. The label associated with the lectotype has the name

Cl. semiannulata struck out by the author and replaced by dunkeri.

There are four unnumbered specimens at Marburg from Bed 15 at Kirch-Gattendorf, remaining from the "several" upon which Schindewolf (1923a) based his description of the species. None is well preserved, being only internal moulds, and the sutures are damaged. Presumably they were used as the basis for Schindewolf's figure (1923b, fig. 4c) when he established Protoxyclymenia.

Interpretation of the species has, until now, been based on either Münster's and Gümbel's figures, or Schindewolf's description.

Other authors have recognised specimens belonging to this genus, notably those listed in the generic synonymy. Lange (1929) figured a specimen as Pro. cf. dunkeri which he claimed came from the delphinus Zone at Enkeberg. This was evolute with numerous weak biconvex ribs, and greatly resembled the description of the species which Schindewolf had given. This specimen cannot be traced, but figured in Pl. 5.36, Figs. 17,18, is a similar, though less well preserved, specimen (MfN) labelled as having been collected by Paeckelmann, in 1925, from "Bed 9" at Enkeberg, and this, by comparison with the specimen figured in Pl. 5.36, Figs. 14-16, Textfig. 5.30I,J, is identified as Genu karpinskii. Also figured in Pl. 5.28, Figs. 8,9,12,13 is another specimen from the Sauerland. This has no ribbing, only concave growth-lines and is more likely to be a Protoxyclymenia. Kolotukhina (1938, p. 683) described Pro. cf. dunkeri from the Clymenia Stufe of Central Kazakhstan, basing her identification on Lange's figure. Freyer (1959) listed a specimen of Pro. cf. dunkeri from Taltitz, Vogtland (East Germany). This was not figured and lacked a suture, but was described as having weak biconvex ribs on the body chamber, and so may be a Genuclymenia too. Sun and Shen (1965) figured what appears to be a large (D = 53.6mm) well preserved specimen which they assigned to Pro. dunkeri. Unfortunately neither can I read the Chinese text nor is the illustration well reproduced, and so no further comment can be made. Certainly the suture (fig. 9) shows that the specimen belongs to this genus.

Chlupáč (1966, p. 95, pl. IV, figs. 2,3b) figured a specimen as Pro. sp. from Moravia, which has a very slender whorl section and a ventro-lateral lobe as deep as the lateral lobe. Petersen (1975, pl. 7, figs. 2,11,12) figured two small specimens from the Piker Hills Formation, Western Australia, which he assigned to Pro. cf. dunkeri. These, however, have very shallow lateral lobes, especially on GSWA F8389 (fig. 2), which seems hardly distinguishable from that shown by Petersen himself (fig. 25) for Clymenia cf. laevigata. Therefore this report cannot be taken as convincing evidence for the occurrence of Protoxyclymenia in Australia.

To summarise, Protoxyclymenia dunkeri is known from few specimens: Münster's original figure showed an example with concave prorsiradiate ribs, the lectotype has weakly biconvex ribs. Lange (1929) figured an example conforming with the lectotype and Schindewolf (1923a) gave a description based on material from the type locality, his Bed 15. The specimen described here from Wäschholz should serve to clear up any doubt as to the nature of Pro. dunkeri. It appears to resemble the poorly preserved lectotype in shell form and ornament, and has a typical Protoxyclymenia suture.

Sun and Shen (1965) and Chlupáč (1966) both described single specimens with more greatly compressed whorl sections than others described here. Each of the specimens listed here could represent a different species but there is insufficient information to develop further such a view.

Specimens assigned to this species by Frech (1902, textfigs. $1a_{1-5}$), from the Clymenia Stufe of Cabrières, belong to Costaclymenia, as may also those described by Wedekind (1908), who reported a "ventral saddle divided by a shallow lobe", and Gortani (1907), who based his identification of Cl. (Cyrto.) cfr. dunkeri on Frech's figures.

Horizon and distribution: The lectotype is from Kirch-Gattendorf, Oberfranken, where Schindewolf (1923a) considered it to occur in the lower Clymenia Stufe. The specimen from Wäschholz was collected loose, but together with Platyclymenia, Trigonoclymenia sp. and Aktuboclymenia sp. suggesting an annulata Zone age. Matrix from the Aktuboclymenia yielded styriacus Zone conodonts (Luppold, pers. comm.).

Other reports of the genus, from the Sauerland (W. Germany), Vogtland (E. Germany), Kazakhstan (USSR), Moravia (Czechoslovakia) and Kweichow (s.w. China) confirm a lower Clymenia Stufe age. However, Lange (1929) recorded a specimen from the delphinus Zone at Enkeberg, and Schindewolf (1952) recorded Pro. sp. from a level which also yielded Platyclymenia and Trigonoclymenia at Mauxion, Saalfeld, Thuringia (East Germany).

Protoxyclymenia serpentina (Münster 1832)

Pl. 5.26, Figs. 10,11, Textfigs. 5.24L,M; 5.25; 5.29D,E

v*	1832	Planulites serpentinus sp. nov. - Münster, p. 12, pl. III, figs. 1a-c.
v	1832	Clymenia serpentina Münster - Münster, p. 74, pl. III, figs. 1a-c (translation of Münster 1832).
v	1843	Clymenia serpentina Münster - Münster, p. 8, pl. IIIa, figs. 1a-c (copy of Münster 1832).

v	1863	Clymenia serpentina Münster - Gümbel, pl. XVII, fig. 9 (only).
?	1892	Clymenia dubia sp. nov. - Loewinson-Lessing, p. 22, pl. II, figs. 3a-c.
?	1914	Clymenia dubia Loewinson-Lessing - Perna, p. 79, pl. III, fig. 16.
?non	1923a	Oxyclymenia serpentina Münster - Schindewolf, p. 475.
non	1937a	Oxyclymenia serpentina Münster - Schindewolf, p. 27.
?	1947	Genuclymenia dubia Loewinson-Lessing - Nalivkina, p. 176, pl. XLV, fig. 1.
?	1962	Protoxyclymenia dubia Loewinson-Lessing - Bogoslovskiy, pl. XXXII, fig. 4.
?	1981	Protoxyclymenia dunkeri Münster - Ruan, p. 122, pl. 30, figs. 7,8.
.	1981	Kosmoclymenia serpentina Münster - Ruan, p. 127, pl. XXXII, figs. 17-19.

Type material: Münster's catalogue (1833, p. 110) lists only one specimen and this, the holotype, is recognised as BSP AS VII 538 (Pl. 5.26, Figs. 10,11) from Schübelhammer, Oberfranken.
Diagnosis: Widely umbilicate Protoxyclymenia with a body chamber which has a compressed section, converging flanks and a subacute venter. The growth-lines are strongly biconvex with each salient equally prominent and a strong midflank sinus, along which develops a shallow depression.

Description: The holotype is evolute with a shallow umbilicus, the umbilical width being 50% of the diameter at all stages. Early whorls have a subcircular cross-section (Textfig. 5.29E), but by a diameter of 50mm the flanks are converging and the whorl section compressed. The body chamber at a diameter of 90mm has an almost triangular whorl section with a subacute venter, the apex of which is slightly rounded and bounded by two barely visible grooves (Pl. 5.26, Fig. 11).

Growth-lines have been eroded from all but the last half whorl where they are biconvex with a deep rounded midflank sinus

(Textfig. 5.29D), along which runs a shallow depression. Periodically growth-lines are strengthened (Fig. 10) to form faint ribs.

The suture, revealed by polishing at a diameter of ca 50mm lacks the sharp pointed base to the lateral lobe. An example from Beil is illustrated in Pl. 5.28, Textfigs. 5.24L,M. This (KW 2077) closely resembles the holotype. Inner whorls are smooth. Growth-lines at a diameter of 60mm are biconvex, rursiradiate (Textfig. 5.24L). Weak plicate ribs are visible on the internal mould of the body chamber, and the venter (D = 67) is weakly tabulate, bounded by two very shallow grooves, and has upon its internal mould indications of weak U-shaped ribs. The suture (Textfig. 5.24M) consists of a shallow asymmetric lateral lobe, and a flat ventral saddle. Another example (BM C34762, Pl. 5.20, Figs. 16, 17) from Schübelhammer, may belong to this species.

Dimensions:

	D	U	WW	WH
Holotype, BSP AS VII 538, Pl.5.26 Figs.10,11.	97	47.8	15.5	25.5
	89	41.5	18	26
	67	32.5	13	18
	57.5	34.3	12	14
	36.5	18.1	8.5	10.3
	27.5	12.5	7.3	8.1
	20.0	8.5	5.0	6.5
	13.8	6.0	3.8	4.8
KW 2077, Pl.5.28 Figs.14,15.	67		14.5	17.5

Discussion: The holotype is a specimen which was illustrated well by Münster in 1832 (pl. VI, figs. 1a,b) being a more accurate representation than many of his other figures. It gives evidence of the type of elaboration Münster's artist used, and is a help in interpreting other figures that he drew. The ornament of the inner whorls is all conjectural and the midflank sinus of the growth-lines is too shallow. There is no evidence for the apertural shape, and the cross-section at the aperture is too compressed.

The nature of the venter is drawn well, although where shown (fig. 1b) in the apertural view, it is not actually preserved.

Gümbel (1863, pl. XVII, figs. 9a,b) also figured this specimen. His artist again drew in the growth-lines of the inner whorls, and completed the venter in the apertural view. The growth-line shape was more accurately represented, though the sutures do not possess the deeply pointed lateral lobes shown.

This species has been completely misinterpreted by all authors this century. Wedekind (1914, p. 51) considered it to be the mature form of Kosmo. undulata. Schindewolf (1923a, p. 475) recognised it as synonymous with Oxy. galeata Wedekind, which has a similar shell shape. Wedekind (1914, p. 52, pl. VII, fig. 5) illustrated the venter of galeata as being acute at a diameter of 25-30mm. This was contradicted by Schindewolf (1923a), but the venter is definitely acute (see Wedekind's photograph) by a diameter of 50mm, at a stage where the venter of Pro. serpentina is still rounded. Furthermore the growth-lines of Kosmo. galeata are not strongly biconvex and it has a pointed lateral lobe.

Kosmo. galeata may be synonymous with another Münster species, Cl. otto (1839, p. 31, pl. II, figs. 9a-c) from Dzikowiec. This is shown as having an acute venter and a Kosmoclymenia type suture. The figured specimen was seen by Gümbel (1863, p. 143) but type material cannot now be traced, so it is better to disregard the name as a nomen dubium.

Schmidt (1924) recorded Oxy. serpentina from the Sauerland but figured no examples and compared the ornament to his new species Cymaclymenia striata var. serpentina, which has growth-lines with a much stronger ventro-lateral salient than on the holotype. It cannot therefore be certain that Schmidt was referring to the same species.

There is great similarity between Pro. serpentina and illustrations of Clymenia dubia by Loewinson-Lessing (1892, pl. II, figs. 3a-e), Perna (1914, pl. III, figs. 16a,b, textfig. 82), and Bogoslovskiy (1962, pl. XXXII, fig. 4); thus they may be synonymous. Clymenia dubia has a suture with an asymmetric but rounded lateral lobe, wide umbilicus (WW/D = 0.56) and a compressed whorl section with two shallow ventro-lateral grooves, giving a hint of a keel. The only difference is that in Loewinson-Lessing's figure these grooves appear at an earlier diameter than on Pro. serpentina. Cl. dubia Loewinson-Lessing is, however, an invalid name since it had been used earlier by d'Orbigny (1850, p. 58), who considered his former Bellerophon dubia (1839, pl. 7, figs, 10, 11) to be a Clymenia. This is unlikely, but I have seen neither figure nor description of it.

Although Protoxyclymenia serpentina has a typical Protoxyclymenia suture it lacks morphological similarity with Protoxyclymenia dunkeri. Comparison is hindered by the lack of material and the poor preservation of the inner whorls of the holotype on which no growth-lines are preserved.

Horizon and distribution: Earlier authors' comments have to be disregarded because of the varied interpretation of the species. Korn (1981a) has recently used this species to name the lowermost zone of the Clymenia Stufe in the Sauerland. The species is known from the lowermost Clymenia Stufe of the Sauerland and Oberfranken (W. Germany).

Genus Kosmoclymenia Schindewolf 1949a

Textfig. 5.28

p 1832 Planulites Parkinson (non Lamarck) - Münster, p. 9.

p 1834 Clymenia Münster - Münster, p. 71.
p 1838 Endosiphonites gen. nov. - Ansted, p. 416.
p 1848 Clymenia Münster - Richter, p. 30.
p 1853 Clymenia Münster - Sandberger, p. 189.
p 1863 Clymenia Münster - Gümbel, p. 140.
p. 1884 Oxyclymenia gen. nov. - Hyatt, p. 312 (rest: Clymenia).
p 1892 Clymenia Münster - Loewinson-Lessing, p. 18.
1896 Oxyclymenia Hyatt - Gürich, p. 327.
p 1897 Clymenia (Oxyclymenia) - Frech, pl. 32a (rest: Clymenia).
p 1902 Oxyclymenia Gümbel - Frech, p. 34, (rest: Cymaclymenia).
p 1907 Clymenia (Oxyclymenia) Münster - Gortani, p. 220 (rest: Cymaclymenia).
p 1908 Clymenia (Oxyclymenia) - Wedekind, p. 605,621, (rest: Cymaclymenia).
p 1914 Oxyclymenia Guembel - Frech, p. 8 (rest: Cymaclymenia, Ornatoclymenia).
1914 Oxyclymenia Gümbel - Wedekind, p. 49.
1923a Oxyclymenia Gümbel - Schindewolf, p. 467.
1924 Oxyclymenia Gümbel - Schmidt, p. 132.
1928 Oxyclymenia Hyatt - Péneau, p. 183.
1929 Oxyclymenia Gümbel - Lange, p. 121.
1949a Kosmoclymenia nom. nov. - Schindewolf, p. 69.
1950 Oxyclymenia Gümbel - Termier and Termier, p. 74.
1957 Kosmoclymenia Schindewolf, p. 144.
1959 Oxyclymenia - Lewowicki, p. 97.
1960 Kosmoclymenia Schindewolf - Kullmann, p. 534.
1960 Kosmoclymenia Schindewolf - Petter, p. 35.
1979 Kosmoclymenia Schindewolf - Korn, p. 400.

Type species: *Planulites undulatus* Münster 1832, by original designation of Schindewolf 1949a, p. 69.
Diagnosis: Member of the family Clymeniidae with a suture (Text-fig. 5.26B) consisting of a low ventral saddle, a very shallow ventro-lateral lobe with the steeper flank on the ventrad side, and a broad U-shaped dorsal lobe.

Description: Shell evolute to subevolute, whorl section circular to compressed, with flanks parallel or subtriangular. The venter may be tabulate or rounded, with or without ventro-lateral grooves continuous ventrally directed flares around the ventro-lateral shoulder, and ventral spines. Growth-lines are generally bi-convex on the flanks, but may also be convex with a ventral sinus.

Both ventral and dorsal wrinkle-layer are known from Kosmoclymenia. Dorsal wrinkle-layer is particularly well shown by an early (lower Clymenia Stufe) species (Kosmo. aff. inaequistriata), an example of which is shown in Pl. 5.29, Figs. 1-3. Approximately 25% of the previous whorl is enveloped, so the wrinkle-layer, a series of prorsiradiate anastomosing ridges, runs from one flank, over the venter, and onto the other flank. Fragments of similar shaped dorsal wrinkle-layer have been seen on many other specimens e.g. Kosmo. subundulata (Pl. 5.23, Figs. 8,9), where it can clearly be seen to cover the thin keel.

Ventral wrinkle-layer is seen much less commonly. It consists of very fine unarranged bumps on the inner ventral shell surface and is most often seen as shallow pits on internal moulds. Examples are shown in Pl. 5.29, Fig. 10, and Pl. 5.23, Fig. 10, which also show a low mid-ventral ridge, corresponding to a groove on the internal shell surface.

The ontogenetic development of the suture (Textfig. 5.24C-E) was shown by Schindewolf (1923b) to progress from an early stage with rounded dorsal, lateral and ventral lobes. The lateral lobe gradually becomes deeper and pointed, and the ventral lobe transforms into a saddle on which secondary ventro-lateral lobes finally develop.

Remarks: Kosmoclymenia is the most commonly occurring clymeniid genus. Numerous species have been described but it is difficult to find in the literature one which has been interpreted correctly. During the course of this study nearly all the type specimens of species of Kosmoclymenia have been examined and the opportunity is taken to describe clearly all of these, and to discuss variability within the genus.

The terms weakly, moderately and strongly biconvex are exemplified in Textfigs. 5.24H, 5.26C, 5.29K, respectively.

Four morphological groups are recognised, distinguished primarily by their growth-line course and shape (Textfig. 5.26). These, however, are not given distinct taxonomic status since the stratigraphic ranges of none of the species described here are known. In a forthcoming paper Korn and Price (?1983) will provide stratigraphic information and formal names for newly proposed taxa.

Species now recognised as belonging to _Kosmoclymenia_ were first described by Münster (1832) from Oberfranken. Later Richter (1848) and Sandberger (1853) reported examples from Thuringia and Dzikowiec (Poland), Petherwin (England) and Enkeberg (Rheinische Schiefergebirge) respectively. Gümbel reviewed all of the clymeniids in 1863 and included numerous species of _Kosmoclymenia_ within the single species _undulata_ Münster, for which he erected the group name Oxyclymeniae, Adscendentes.

Twenty years later Hyatt (1884) formalised Gümbel's group name as _Oxyclymenia_ (see Opinions 1944), which had as its type species _laevigata_ Münster, and included the other Münster species _undulata_ and _dunkeri_. Subsequent authors incorrectly accepted Gümbel as the author of _Oxyclymenia_, interpreting it like his group Oxyclymeniae, rather than like _Oxyclymenia_ Hyatt. Thus Frech, in reporting _Kosmoclymenia_ from Graz (1886), Montagne Noire (1887a, p. 372) and the Carnic Alps (1887b, p. 699) referred to _Cl_. (_Oxyclymenia_) _undulata_, and included the species _laevigata_ and _dunkeri_ within _Cl_. (_Cyrtoclymenia_) Hyatt.

Numerous authors followed a similar pattern (e.g. Wedekind

1914; Schindewolf 1923a, 1937a; Schmidt, 1924; Lange 1929; Nalivkina 1947 (Atlas); Termier and Termier 1950; Lewowicki 1959) until Schindewolf (1949a) pointed out that the correct usage was Oxyclymenia Hyatt, (see Opinions 1944) with the type species laevigata Münster. Therefore it should be treated as a junior objective synonym of Clymenia Münster 1834.

Further reports of Kosmoclymenia have been made from the southern Urals (Loewinson-Lessing 1892), Poland (Gürich 1896), Armorica (Péneau 1928), North Africa, Pyrenées (Schindewolf 1921; Kullmann 1960) and south west China (Sun and Shen 1965).

Group I

This comprises species similar to the type species Kosmo. undulata.

Diagnosis: Two features diagnose this group, the growth-line course and the ventral ornament of mature specimens. Typically the growth-lines are biconvex (Textfig. 5.27B); either the two salients are of equal size and prominence (as on undulata) or the ventro-lateral salient may be more sharply curved and project further towards the aperture (subundulata). A line drawn between the two salients is either radial or slightly prorsiradiate. The venter always has fewer growth-lines than the flanks; it is bounded by two lines running around the ventro-lateral shoulders, and between these are a series of semicircular sinuses. This is the "Externband" of German authors, which has recently been shown by Korn (1979) to be the bases of spinnaker-shaped spines projecting from the venter. Such a spine is illustrated in Pl. 5.21, Figs. 3,8. The growth-line shape, and examples of Kosmo. undulata can be seen in Pl. 5.22, Figs. 5-10 and Pl. 5.23, Figs. 1,2; the ventral band is illustrated in Pl. 5.23, Figs. 3,9, Pl. 5.29,

Fig. 4, and various representatives of the group are shown in Pl. 5.24 and 5.29.

Species recognised as belonging to this group are:

*	undulata	Münster 1832, p. 9, pl. II, figs. 9a-c.
s	elegantula	Wedekind 1914, p. 52, pl. II, figs. 10a,b.
	inaequistriata	Münster 1832, p. 10, pl. II, figs. 4a-c.
	lamellosa	Wedekind 1914, p. 53, pl. IV, fig. 7.
?	linearis	Münster 1832, p. 11, pl. II, figs. 5a-c.
	pattisoni	Selwood 1960, p. 165, pl. 27, fig. 1.
	subundulata	Wedekind 1914, p. 50, pl. IV, figs. 5,6.
	sp. nov. a	Pl. 5.24, Figs. 5,6.

Those prefixed by an s are considered as synonyms.

Group II

This group has a characteristic growth-line shape and venter.

Diagnosis: The growth-lines are biconvex (Textfig. 5.26D), with the salient on the dorsad part of the flank being wider and more prominent. A line joining the two salients can be slightly prorsiradiate but, more usually, is radial. Flank and ventral growth-lines form in the ratio 1:1 and there is no evidence of spines or flares projecting from the ventral surface. The nature of the venter is clearly visible in Pl. 5.25, Fig. 16. The whorl section is generally compressed, with flattened, converging flanks.

The two established species, Kosmo. sublaevis and Kosmo. wocklumeri, fall at opposite ends of the spectrum of variation within this group. Kosmoclymenia sublaevis is close to Group I, except that there are no ventral spines. It has slightly prorsiradiate biconvex growth-lines, and a venter bounded by two fine lines (Pl. 5.20, Figs. 3,4, Pl. 5.25, Figs. 5,6) and Kosmo.

wocklumeri has strongly rursiradiate, almost concavo-convex growth-lines, and no ventral band (Pl. 5.25, Figs. 16,17). Other, unnamed species, intermediate in morphology between these two, are illustrated in Pl. 5.25.

Species recognised as belonging within this group are:

?	carinatus	Ansted 1838, p. 419, pl. VIII, fig. 2.
?	coronata	Schmidt 1924, p. 135, pl. VII, fig. 6.
	sublaevis	Münster 1832, p. 10, pl. II, figs. 3a-b.
	wocklumeri	Wedekind 1914, p. 58, pl. VII, fig. 6.

Group III

Diagnosis: The growth-lines of this group are strongly biconvex (Textfig. 5.29A) with a deep sinus on the flanks and over the venter. The flank to venter growth-line ratio is 1:1. The whorl section is compressed with parallel or converging flanks, and the narrow venter is tabulate, or rounded, bounded by ventro-lateral grooves.

Species recognised as belonging to this group:

bisulcata	Münster 1840, p. 93, pl. XVII, figs. 6a,b.
colubrina	Lange 1929, p. 125, pl. 3, fig. 39.

Other species which may belong here, but which are poorly known are:

galeata	Wedekind 1914, p. 52, pl. VII, fig. 7.
otto	Münster 1839, p. 31, pl. II, figs. 9a-c.

Group IV

Diagnosis: The growth-lines of this group are only weakly biconvex (Textfig. 5.29F), becoming almost concave in some species with the dorsad salient barely developed. A line drawn between the two salients is strongly prorsiradiate , and the ventro-lateral salient runs strongly forwards. There is a deep sinus over the venter and the ratio of flank to ventral growth-lines varies between 1 and 4:1. Continuous flares (Pl. 5.21, Figs. 1,2), or short blunt spines (Pl. 5.21, Figs. 4,5,7), or no spines (Pl. 5.27 Figs. 1,2) are formed on a tabulate venter, which is commonly bounded by ventro-lateral grooves.

Only two species in this group have names, and they have lain unused since their establishment, over 140 years ago.

semistriata	Münster 1839, p. 11.
similis	Münster 1839, p. 11.

Specimens now recognised as belonging to this group have formerly been referred to as bisulcata Münster, e.g. Schindewolf 1923a, Selwood 1960.

Group uncertain.

There are several available species names which have not been allotted to any of the above groups:

cristata	Richter 1848, p. 31, pl. III, fig. 89, pl. IV, figs. 91-3, Bohlen, Thuringia.
lamellosa	Wedekind 1914, p. 53, pl. 4, fig. 7, Hövel, Sauerland.
pygmea	Münster 1832, p. 6, pl. 1, figs. 2a-d, Geigen, Oberfranken.
parvula	Münster,1832, p. 12, pl. II, figs. 7a-c, Elbersreuth, Oberfranken.
sublinearis	Münster 1832, p. 11.
tabulata	Sun and Shen 1965, p. 56, pl. II, fig. 1, 14, Kweichow, s.w. China.
tenuistriata	Münster 1839, p. 11, Heinersreuth/Schübelhammer, Oberfranken.

Original descriptions of most of these species were sketchy and no definitive material has been found.

cristata: Richter (1848) figured a complete, but distorted example of this species (pl. III, fig. 89,90) and two fragments (figs. 91-3). These are not necessarily conspecific, but the type material, now housed at Bernau (DDR) (information from D. Weyer, Magdeburg) has not been examined. The whole specimen (figs. 89, 90) is proposed as the lectotype. This is clearly a Kosmoclymenia and has compressed converging flanks with a tabulate venter bound by two ventro-lateral grooves. The growth-line shape is not visible on the figure but Richter's description best fits those of Group IV. The tabulate venter alone is sufficient to show that this species is not synonymous with Kosmo. bisulcata Münster, which was suggested by Schmidt (1923).

lamellosa: Wedekind (1914) diagnosed this species by its lamellose growth-lines which were "straight, almost concave on the flanks, with a strong ventro-lateral salient". This may place this species in Group IV, but the sculpture is not clearly visible on Wedekind's figure (pl. 4, fig. 7) of the small specimen proposed here as the lectotype. The specimen has not been seen. Wedekind collected the specimen from the same level as Prog. aegoceras, and compared it with specimens collected from a similar level in the Carnic Alps.

pygmea: This small species has been regarded as a Kosmoclymenia (Schindewolf 1923a, Gümbel 1863). Planulites pygmeus, as described by Münster (1832) from two specimens 18 and 5mm in diameter, was small, evolute with a compressed whorl section and 30 raised growth lirae in the whorl prior to a diameter of 16mm. There were acknowledged similarities to Cl. laevigata, and the suture Münster figured (pl. II, figs. 6) consisted of a broad lateral lobes and a low ventral saddle, which is closer to Clymenia than Kosmoclymenia. Later Münster (1839, p. 7) reported a newly found specimen "twice as large as the illustrated specimen" and it may have been this that Gümbel figured (1863, p. 141, pl. XVII, figs. 7a-d) as "Münster's original". This (BSP) is clearly a Kosmoclymenia.

The Münster Collection at Cambridge contains two species: one (SM H7340) is a juvenile Kosmoclymenia and the other (SM H7337-9) is a small evolute species of Clymenia with slowly increasing whorls. Münster's type series may also have contained these two forms. I have never clearly seen growth-lines on this species of Clymenia, which points to Münster's original description being of a juvenile Kosmoclymenia, but the suture he figured contradicts this.

In the absence of a clear original description, or specimens which can be unambiguously identified as from the type series this species is regarded as a nomen dubium.

parvula: This species, unmentioned by Gümbel (1863), was illustrated by Münster, but the specimen figured is too small to be identified. Münster's description lacked comments on the suture; growth-lines were convex, rursiradiate, and there were irregular ribs which formed an acute sinus over the venter. Münster (1843) revised his interpretation of this species, and recognised that it was a gastropod. Three small specimens from Cambridge (SM H10403-5) labelled as parvula can only be determined as Kosmoclymenia. Therefore this species is regarded as a nomen dubium.

sublinearis: This species was described by Münster (1832, p. 11) as "transitional between Plan. sublaevis, linearis and inaequistriatus", and diagnosed by its smooth shell, fine wavy growth-lines, and absence of ribs. Such a description is highly ambiguous, and since no material can be traced, nor is there any trace of type material, the species is regarded as a nomen dubium.

tabulata: This species, of which only the poorly preserved holotype is known, was diagnosed by its tabulate venter, oval whorl cross-section and concave growth-lines. The details of the Chinese description are illegible to me, but the species probably belongs to Group I.

tenuistriata: This species was not figured by Münster but described simply as "similar in shape to undulata, more involute, remains small, and has growth-lines visible only with a lens". Gümbel (1863, pl. XVII, figs. 8a-d) figured a small specimen as "Münster's original" and this can be interpreted only as Kosmoclymenia juv. and is regarded as a nomen dubium.

Kosmoclymenia Group I

Kosmoclymenia undulata (Münster 1832)

Pl. 5.21, Figs. 3,8, Pl. 5.22, Figs. 5,6,7,8,9,

Textfigs. 5.27A-D, 5.28

nom. nud.	1831	Planulites undulatus sp. nov. - Münster, p. 182.
	1832	Planulites undulatus sp. nov. - Münster, p. 9, pl. II, figs. 2a-c.
	1834	Clymenia undulata Münster - Münster, p. 71, pl. II, figs. 1a-c (copy of Münster 1832).
	1843	Clymenia undulata Münster - Münster, p. 5, pl. IIa, figs. 2a-c, (copy of Münster 1832).
non	1853	Clymenia undulata Münster - Sandberger, p. 189, pl. VIII, figs. 1a,b.
pvnon	1863	Clymenia undulata Münster - Gümbel, p. 140, pl. XVII, figs. 1-9, pl. XVIII, fig. 12.

non 1871 Clymenia undulata Münster - Tietze, p. 133, pl. XVI, fig. 9.

non 1876 Clymenia undulata Münster - Roemer, pl. 36, figs. 1a,b, 2a-c, (same specimens as figured by Tietze and Sandberger respectively).

non 1897 Clymenia undulata Münster - Foord and Crick, p. 23, fig. 4. (This work contains an extensive list of all previously published uses of the specific name undulata, and all species then considered to be synonymous with it. None of the references can be taken at face value; most were poorly illustrated or not illustrated at all, so that no useful opinion of them can be formed today.)

non 1897 Clymenia (Oxyclymenia) undulata Münster - Frech, pl. 32a, figs. 1a-c.

(?) 1907 Clymenia (Oxyclymenia) undulata Münster - Gortani, p. 220, pl. II(VII), figs. 6,7.

1914 Oxyclymenia undulata Münster - Wedekind, p. 50, pl. 4, figs. 5a,b, 6a-c.

vp 1923a Oxyclymenia undulata Münster - Schindewolf, p. 468.

p 1924 Oxyclymenia undulata Münster - Schindewolf, p. 133, textfig. 5a (non 5b).

? 1937a Oxyclymenia undulata (Münster) - Schindewolf, p.27.

non 1950 Oxyclymenia undulata (Münster) - Termier and Termier, p. 74, pl. CLIX, figs. 36,a, pl. CLVII, fig. 34.

? 1956 Oxyclymenia sp. - Glenister, pl. 5, fig. 11.

non 1957 Kosmoclymenia undulata (Münster) - Schindewolf, p. L44, fig. 41.8.

1959 Oxyclymenia undulata (Münster) - Lewowicki, p. 97, pl. 1, figs. 6,10,11 (not seen).

(?) 1957 Kosmoclymenia undulata (Münster) - Freyer, pl. Xb, fig. 3.

p. 1960 Kosmoclymenia undulata (Münster) - Kullmann, p. 534, pl. 8, figs. 6, ?fig. 7.

?p. 1965 Kosmoclymenia undulata (Münster) - Sun and Shen p. 53, pl. II, ?fig. 7, fig. 8, non fig. 9.

1979 Kosmoclymenia undulata (Munster) - Korn, p. 400, figs. 1,2.

Type material: A neotype, SMF, from Bed 23, Reigern Quarry, Sauerland, will be proposed. No certain syntype material has been identified.

Remarks: The type series consisted of four specimens, one of which was sectioned (Münster 1833). Six Münster specimens designated as Cl. undulata, with their original labels still attached, were available for study. None conforms with Münster's original illustration and description. Since it is important that this, the type species, be clearly defined a neotype will be proposed, and this conforms more with accepted usage of the species name than the original description. An ideal solution would be to use as the neotype a specimen from Schübelhammer, Oberfranken, which resembles Münster's figure, but no such specimen has been found.

Diagnosis: Evolute Kosmoclymenia which has an umbilical width ranging from 45-55% of the diameter (Textfig. 5.28A). The whorl section is circular up to a diameter of 20mm, thereafter becoming compressed with a clearly defined umbilical wall and latero-umbilical shoulder, flattened, slightly converging flanks and, by a diameter of 70mm, a tabulate venter. Growth-lines are radial, biconvex, with a shallow broad sinus between the two equally prominent salients, which are centred near to the shoulders of the flanks at diameters greater than 40mm. The ratio of flank to ventral growth-lines is ca 20:1. Small isolated spinnaker-shaped spines are formed on the venter.

Description: The description is based on four specimens (HU P82.7, 9, 11, SMF). Only the neotype (SMF) was collected in situ, from Bed 23, Reigern Quarry, Hachen, Sauerland. The others were collected loose, but are probably from Bed 33, at Reigern (see Chapter 7).

The shell coiling is serpenticonic and evolute, with the ratio U/D increasing in early whorls, and then reducing from 0.6 at a diameter of 10mm, to 0.5 at a diameter of 40mm (Textfigs. 5.27A, 5.28a). Whorl shape in early whorls is circular, becoming compressed at diameters between 40 and 50mm. A distinct steep umbilical wall, subparallel flanks, and a tabulate venter bounded by shallow grooves, are all developed by a diameter of ca 70mm.

Growth-lines are described from the neotype. Early whorls, up to a diameter of ca 15mm, have a smooth shell; then up to a diameter of ca 20mm there are thin, lirate straight, radial growth-lines, with a spacing of 0.5mm, which amounts to ten times their width. After a diameter of 20mm the growth-lines are more closely spaced, and assume a weakly biconvex course (Textfig. 5.27E), with a ventral sinus.

None of the four specimens has exactly similar growth-lines and the following comparisons were made at a radius of 25-30mm. This variation is not a function of the growth-stage achieved on any particular specimen, since the differences in ornament are persistent throughout growth. Growth-line counts were made over a distance of 10mm, near the ventro-lateral shoulder. There is insufficient material to determine whether this variation has any stratigraphic significance, and it is treated as intraspecific variation.

Growth-lines on the neotype have a frequency of 3.2 per mm and are bunched into groups of 6. The bunches form very low ribs 2mm wide, separated by two, more widely spaced, growth-lines. Faint ribs, numbering 5 per centimetre, are also present on the internal mould, especially over the ventro-lateral shoulder.

The strongest ribs are visible on the specimen (HU P82.9) from which the ventral spines are described below (Pl. 5.21, Figs. 3,8). Growth-lines have a frequency of ca 9 per mm, bunched into groups of 10-12. There are eight low ribs per centimetre.

The specimen illustrated in Pl. 5.22, Figs. 6,7, has no ribs, and the growth-line frequency is 7 per mm. Lastly the specimen in Pl. 5.22, Fig. 5, has a similar growth-line spacing, but with weak ribs developed on the inner whorls only.

The striking feature of this genus, the spinnaker-shaped ventral spines, was first described only recently by Korn (1979). A single spine is illustrated in Pl. 5.21, Figs. 3,8. It is preserved on this specimen (HU P82.9) from Reigern at a whorl height of 24mm and a whorl width of 22mm. The spine is triangular in side view, with a height of 15mm, and a maximum length of 10mm. There are four or five weak ribs running parallel with the leading (apertural) edge. The shape of the apicad edge changes at a distance of 5mm away from the venter, below this point the spine seems to have curved round along the semicircular lines of the ventral band to join a similar spine on the other flank (Pl. 5.21, Fig. 6). Above this level the spines may have been separated.

The specimen which Korn figured (1979, figs. 1a,b, 2a) has spines with an asymmetrical lateral profile, and an apicad side with a constant slope, interpreted as showing that the spine ran continuously from one side of the venter to the other.

Only one highly weathered specimen (BM C83295), from the various Münster Collections, has been identified as belonging to this species. It is poorly preserved (Pl. 5.22, Figs. 8,9) but is identified by its whorl section. The inner whorls are circular and at the maximum diameter preserved are compressed with a distinct steep umbilical wall, angular ventro-umbilical shoulder and tabulate venter showing the remnants of a ventral band. This specimen was labelled as <u>Cl</u>. <u>laevigata</u> and thus cannot be considered to be from the type series. It is too poorly preserved to warrant use as the neotype.

Dimensions:

	D	U	WW	WH
Neotype, SMF	75	37.4	19.2	21.7
Pl. 5.22,Figs.6,7,	54.5	27.0	13.1	15.2
(all measurements	40.0	19.8	10.2	11.5
exclude the shell	27.8	14.6	7.4	8.1
thickness)	19.9	10.9	5.4	5.4

	D	U	WW	WH
	15.1	8.5	3.7	3.9
	11.2	6.36	2.90	2.72
	8.4	4.70	2.14	1.84
	6.3	3.7	1.5	1.60
	4.91	2.36	1.44	1.31
	3.4	1.64	1.04	1.12
Münster 1832, pl. II, figs. 2a,b	59	23	12.5	21
	50	19.5	-	19.5
	43	17.5	-	16.5
Wedekind 1914, p. 51.	87	44	20	26
	69	32	16	21
	27	12	8.9	9
Schindewolf 1923a, p. 470	43	18	12.5	13.5
BM C83295, Pl. 5.22 Figs. 8,9.	80	-	20	28
HU P82.7, Pl. 5.22, Fig. 10.	44.8	21.2	13.0	14.6
HU P82.11, Pl. 5.22 Figs. 5,6.	54.3	26.7	14	16.4
	36.9	18.9	10.3	9.2
	26.8	14	7.1	7.8
	14.2	7.7	3.83	3.6
	7.85	4.16	2.04	2.11

Discussions: The reasons why Münster's definition of the species has been disregarded need a full explanation. Failure to define Kosmo. undulata would mean that the type species would be a nomen dubium, and thus the genus Kosmoclymenia would fall. This would be very unsatisfactory from the point of view of stability of nomenclature.

Münster's earliest usage of the name (1831) lacked a description. This was remedied in the following year (1832) when a figure and description were published. The figure (pl. II, figs. 1a-c) shows an evolute Kosmoclymenia with the ratio U/D being 0.40 at a diameter of 60mm. Growth-lines are shown as concavo-convex on the last whorl, with a ventral band. The description (p. 9) states that "the maximum diameter is 1-2 inches" (contra figs. 1a,b). "The growth-lines are wavy with a spacing equal to their width, and over the venter have a semicircular course, where they are more widely spaced than on the flank, and bounded by two lines". Münster states that the figure correctly shows the proportions of whorl height and width. His catalogue (Münster 1833) recorded four specimens, one of which had been sectioned. This last specimen (BSP AS VII 539, Pl. 5.30, Fig. 12) is probably the same as that figured by Gümbel (1863, pl. XVII, fig. 1g), but this can only be identified as a clymeniid.

Gümbel (1863) figured Münster's "original" specimen (pl. XVII, figs. 1a,b,d) but this does not resemble the original figure. It has biconvex, rursiradiate growth-lines which would now cause it to be included in Group II. The well drawn growth-lines (fig. 1d) clearly show the absence of a ventral band. The specimen cannot be traced in Munich.

There are four specimens (SM H10388-91) at Cambridge labelled as Cl. undulata. Three of these are figured here: H10388 (Pl. 5.27, Fig. 18, Textfigs. 5.29H,I) has concave prorsiradiate growth-lines, a tabulate venter and vestiges of spine bases and would be included in Group I; H10389 (Pl. 5.23, Figs. 5-9) is a small specimen which has weakly biconvex growth-lines, a ventral band and would be placed in Group I; H10390 (Pl. 5.28, Figs. 8,9,11, Textfigs. 5.27B,C) has concave radial growth-lines, a ventral band and would be included in Group I; and lastly H10391 is a polished fragment showing an oval whorl section and Kosmoclymenia suture. None of these resembles Münster's figure. There are other examples of Kosmoclymenia at Cambridge but these have been given other specific names, e.g. inaequistriata, parvula and serpentina.

In the Münster Collection at the British Museum (NH) there are only two specimens labelled as Cl. undulata: one, BM 81827 is a weathered internal mould, and the other, BM 81852, is a juvenile specimen reaching only 18mm in diameter.

No specimens were encountered in the Münster Collection at Berlin which resemble Münster's figure, or which were labelled as Cl. undulata.

The sectioned specimen from Munich, figured by Gümbel (1863) has been mentioned above, and Korn (1979) stated that BSP AS VII 539 was figured by Münster (1832, pl. 11, fig. 6). This is a weathered internal mould and of little use in defining the species.

To illustrate Cl. undulata Roemer (1876, pl. 36, figs. 1a,b) chose a specimen from Dzikowiec, Poland, rather than copying Gümbel's (1863) figures, as he did for Cl. angustiseptata, striata etc. At a diameter of 75mm this large well preserved specimen has a subcircular whorl section, an umbilical width amounting to 50% of the diameter, a ventral band with a high flank to venter growth-line ratio, weakly biconvex growth-lines and closely spaced ribs. An example like this from Braunau, Kellerwald, is illustrated in Pl. 5.30, Figs. 14,15 as Kosmo. aff. undulata.

The next author to figure Cl. undulata was Frech (1897, 1902). His description was, however, brief and restricted to illustrations of two specimens; one a fragment (1897, pl. 32a, figs. 1a,b) showing biconvex growth-lines, and another (fig. 1c) showing a constriction on the body chamber on a small specimen from Schübelhammer.

Wedekind (1914) retracted the brief description of the species he had given in 1908, and figured (pl. 4, figs. 5,6) poorly preserved specimens from Dasberg and Dzikowiec. He claimed that his examples fully resembled Münster's, and had a circular whorl section up to a diameter of 40mm, and a compressed whorl section thereafter. The growth-line course showed a weak ventro-lateral salient. By contrast his new species Oxy. subundulata had growth-lines with a strong ventro-lateral salient and an oval whorl section (but see description below).

Schindewolf (1937a) recognised Kosmo. undulata from only the lower Wocklumeria Stufe at Oberrödinghausen. Later (1949a) he realised that Oxyclymenia Hyatt, with Plan. laevigatus Münster as its type species, could not be included within this large group of clymeniids with pointed lateral lobes. He erected Kosmoclymenia to contain them, with Pl. undulatus Münster as its type species.

A number of similar nomenclatorial revisions came out of Schindewolf's work on the clymeniid part of the Treatise, published in 1957. This contained several new illustrations of Famennian ammonoids, amongst which was Kosmo. undulata (p. L44, fig. 41.8). The specimen (MfN c597) upon which this drawing was based is illustrated in Pl. 5.24, Figs. 14,15, Textfig. 5.27H,I. For some reason, which was never explained, Schindewolf revised his conception of Pl. undulatus Münster, perhaps because of a re-examination of the original figure, or specimens, an approach which was also adopted in his other post - War paper on Famennian ammonoids (Schindewolf 1952).

It would be easy to accept this specimen from Ense as a neotype for Pl. undulatus if the growth-lines resembled those in Münster's figure. They do not. These and the shell form conform with Wedekind's description of Kosmo. subundulata, the type specimen of which also came from Ense.

There seems little reason for upsetting established practice (admittedly only four papers, Schindewolf 1923a, Schmidt 1924, Schindewolf 1937a, Korn 1979) and accepting Schindewolf's reinterpretation of the species. He gave no formal redescription, the specimen is not from the type locality, nor does it fully resemble the original figure. A neotype has been chosen to stabilise nomenclature, and legalise the accepted practice of 65 years standing.

Sun and Shen (1965) figured a number of specimens which they referred to Kosmo. undulata. Of these IV 4071 (pl. II, fig. 7, textfig. 10) has the correct whorl cross-sectional shape, but IV 4073 (pl. II, figs. 9a,b) has growth-lines which continue uninterrupted over the venter, and it would therefore be placed in Group II.

Horizon and distribution: Matrix from the neotype was found to contain conodonts of the costatus Zone. The species is known from Devon (England), Sauerland, Kellerwald, Oberfranken (W. Germany) and Kweichow (s.w. China).

Kosmoclymenia subundulata (Wedekind 1914)

Pl. 5.21, Fig. 6; 5.23, Figs. 5-9; 5.24, Figs. 12, 13, 16-18; 5.27, Fig. 18; 5.28, Figs. 2,3,6,7,10,11; Textfigs. 5.27B,C,H,I;5.28

*	1914	Oxyclymenia subundulata sp. nov. - Wedekind, p. 51, pl. 4, fig. 4.
?v	1923a	Oxyclymenia subundulata Wedekind - Schindewolf, p. 471, pl. XVIII, figs. 8,9.
	1924	Oxyclymenia undulata var. subundulata Wedekind - Schmidt, p. 134, fig. 5c.
?	1929	Oxyclymenia sedgwicki Münster - Lange, p. 121, pl. 3, figs. 37,a.
(?)	1947	Oxyclymenia subundulata Wedekind - Nalivkina, p. 180, pl. XLV, fig. 10, fig. 51.
.	1957	Kosmoclymenia undulata Münster - Schindewolf, p. L44, fig. 41,8.
?p	1960	Kosmoclymenia sedgwickii Münster - Petter, p. 36, pl. VI, figs. 1,a, 3,a, 6,a, 10,a,b; pl. VII, figs. 1,a,b, 5,a, 10; fig. 4F.
?	1960	Kosmoclymenia sedgwickii Münster - Kullmann, p. 535, pl. 8, figs. 4,5.

Type material: The specimen figured by Wedekind (1914, pl. 4,

fig. 4) from Ense, Kellerwald, is proposed as the lectotype.
Diagnosis: Kosmoclymenia with an oval whorl section, a poorly developed umbilical wall, and a ventral band.

Description: The lectotype is poorly preserved, the last whorl being almost devoid of shell, and polished to show the sutures. A second specimen from the type locality (Pl. 5.24, Figs. 14,15) is available, and two specimens from Schübelhammer (Pl. 5.27, Fig. 18; Pl. 5.28, Figs. 2,10,11) and one from Hövel (Pl. 5.28, Figs. 3,6,7).

The lectotype is evolute, with a ratio U/D of 0.48 at the maximum diameter of 57.5mm. Wedekind (1914, pl. 4, fig. 4c) showed a whorl section (the inner part of which must be conjectural since the specimen is unbroken) which at the maximum diameter had flattened, weakly converging flanks, a shallow umbilical wall and a flattened venter. The ratio WW/WH is 0.64. Faint growth-lines are preserved at a diameter of ca 35mm, where they are biconvex with the ventrad sinus occupying most of the flank and the ventro-lateral salient being the most prominent. The suture is of the normal Kosmoclymenia type.

The specimen from Ense (MfN c597, Pl. 5.24, Figs. 14,15, Text-fig. 5.27H,I), figured by Schindewolf as Kosmo. undulata (1957, fig. 41.8) is better preserved than the lectotype. The whorl section is similar to the lectotype, but the whorl width is greater, the flanks less flattened, and the venter more tabulate. Growth-lines are weakly biconvex but their course changes at a diameter of ca 25mm (Textfig. 5.27H,I). Prior to this point the umbilical wall is only weakly developed and the growth-lines are prorsiradiate with a broad sinus occupying most of the flank and a narrow, prominent ventro-lateral salient. Half a whorl later, at a diameter of ca 35mm, the umbilical wall is steeper and more clearly defined and the salient situated on the dorsad part of the flank has expanded at the expense of the flank sinus. Here the growth-lines are less prorsiradiate, and the ventro-lateral salient less prominent. The ratio of growth-lines on flank and venter is approximately 4:1, and the flank growth-lines are widely spaced, numbering 2.5 per mm at a diameter of ca 30mm. Faint plicate ribs are visible on the internal mould of the body chamber.

Two specimens from Kirch-Gattendorf, figuredand described as Kosmo. subundulata by Schindewolf (1923a) are referred to Kosmo. inaequistriata (see below).

Two specimens from the various Münster Collections have been identified as Kosmo. subundulata (SM H10389 and H10390). The larger of these two (H10390, Pl. 5.28, Figs. 8,9,11) has inner whorls and shell material which have been lost by stylolitisation but a section through the outer whorls is shown in Textfig, 5.27C. Early whorls have a rounded whorl section and an umbilical width amounting to 50% of the diameter. By a diameter of 20mm the umbilical width has reduced to 40% of the diameter and the whorl section has become oval, with a ratio WW/WH of 0.8. The venter is tabulate after a diameter of approximately 30mm. Growth-lines (Textfigs. 5.27B,C) are radial, weakly biconvex but a broad shallow sinus occupies most of the flanks. A ventral band is present (Pl. 5.28, Fig. 11) where there are paired semicircular sinuses. The flank to venter growth-line ratio is 2:1 at a diameter of 30mm. The suture has not been observed, and there is no ribbing or secondary ornament.

The other specimen of Kosmo. subundulata (SM H10389, Pl. 5.23, Figs. 5-9) is remarkably well preserved, showing growth-lines, ventral band and wrinkle-layer structures. The shell was at some point subject to damage, and subsequently repaired. It still retains the fine detail and relief of the growth-lines.

The whorl section is circular in inner whorls, but by a diameter of 25mm has become compressed. This and the growth-line shape confer the specific diagnosis. The growth lirae are weakly biconvex and prorsiradiate, numbering 4 per mm on the ventro-lateral shoulder at a diameter of 30mm. The lirae visible on the photographs (Pl. 5.23) are not in fact the growth-lines. These are clearly visible only with a microscope (but see Fig. 8) and are very fine striations, numbering four or five, running between the lirae. Obviously what are referred to elsewhere in this chapter as growth-lines may, on this evidence, in fact be the second order structures, lirae. There is a series of single semicircular growth-lines comprising the ventral band, numbering 28 in the half whorl prior to a diameter of 30mm. The flank to venter growth-line ratio is 4:1. A <u>Kosmoclymenia</u> suture is visible on the inner whorls (Fig. 5).

The dorsal wrinkle-layer is visible in Fig. 9, formed as the dorsal external surface of one whorl enveloped the ventral surface of the previous whorl. The wrinkle-layer consists of a series of anastomosing ridges running transversly across the venter. These are bounded on the flank by the umbilical seam, the trace of which can be seen in Fig. 8. Running along the midline of the venter is a thin string-like keel, approximately 0.5mm in diameter, which the wrinkle-layer covers (Fig. 9).

The specimen suffered at least four interruptions to its continual growth, indicated by the lack of parallelism in some adjacent growth-lines (Fig. 7). The major discontinuity occurred three-quarters of a whorl before the present aperture, where there was an oblique fracture of the shell (Figs. 5,8,9). The damage appears to have been rapidly repaired, shown by the irregularly and widely spaced growth-lines. Where the new shell is joined to the old it overlaps and appears to be cemented to the internal side, possibly caused by a retraction of the mantle edge. Normal ventral ornament was not formed during the period of repair, there being no ventral band and growth lirae running continuously from the flanks over the venter. The wrinkle-layer keel runs undisturbed over this region, showing that it was formed after the rupturing of the shell.

A small specimen (KW 2070), collected from "low" in the Clymenia Stufe at Hövel, has a flank:venter growth-lirae ratio of only 2:1 (Pl. 5.28, Figs. 3,6,7). One specimen from Schübelhammer in the Münster Collection at Berlin, referred to Kosmo. semistriata, shows particularly well the spine bases on the venter (Pl. 5.21, Fig. 6). These are paired ventral growth-line sinuses which are preserved as lunate ridges, the spines having broken off. Between them are very fine growth-lines of similar shape, and ridges (Fig. 6) running from the spine base then converging on and running parallel to the midline of the venter. The growth-lines on the flanks coinciding with the spine bases are more widely spaced, and there are plicate ribs on the internal mould of body chamber. Strong ventro-lateral grooves are not developed in this specimen (Pl. 5.27, Figs. 10-12), but the growth-lines do show the strong salient at the margins of the tabulate venter, and are concave rather than biconvex, over the flanks.

Dimensions:

	D	U	WW	WH	A
GPI, Pl.5.24,Fig.16.	57.5	22.5	14	22	
MfN, c597, Pl.5.24	51.2	20.0	13	18.1	15.6
figs. 14,15.	35.8	14.4	ca10.5	12.5	21.2
		10.3	8.1	10.7	17.3
SM H10388	32	13.4	7.4	10.9	
SM H10389	31.4	13.3	8.7	10.4	
	23.7	9.6	7.4	7.2	
SM H10390	42.5	17	ca10.3	14.7	12.8
	29.5	11.5	8.8	10.4	9.2
	20.3	8.4	6.1	7.4	
MfN, Pl.5.27,Figs. 10-12.	24	11	7.5	8.5	

Discussion: The lectotype of this specimen is so poorly preserved that there is an argument for declaring Kosmo. subundulata to be a nomen dubium. However, since this is one of the few species for which a type specimen can be identified with any certainty the name is retained.

Schindewolf (1923a) was the first author to discuss this species at length. However, two specimens collected by him from Bed 18 (upper Clymenia Stufe), Kirch-Gattendorf, are described below as Kosmo. inaequistriata. He identified (1937a) further examples from the lower Clymenia Stufe, and the lower Wocklumeria Stufe. Also described above was the specimen which he figured in the Treatise (1957, textfig. L 41.8) as Kosmo. undulata. The reason for including it here has already been discussed (see Kosmo. undulata, above).

Three species were included in synonymy with Kosmo. subundulata by Schindewolf (1923a): Cl. sedgwicki (sic) Münster, Oxy. subundulata var. elegantula Wedekind and Oxy. lamellosa Wedekind. No explanation was given for the inclusion of Cl. sedgwicki, in spite of the fact that Münster's figured specimen was present in the Munich Collections (BSP AS VII 558). It is recognised to be a goniatite, Pseudoclymenia.

Lange (1929) and all subsequent authors have used sedgwickii as the valid name for the species, it being the apparent senior synonym. Lange based his description of the species on over 100 examples, but figured only one (1929, pl. 3, figs. 37,a). This large, well preserved specimen shows ribs on the body chamber, just as the specimen in Pl. 5.24, Figs. 17,18 does, and is probably referable to Kosmo. inaequistriata, also.

Lange also figured a single specimen from Beil as cf. Oxy. sedgwickii (pl. 3, figs. 38,a) which he had collected from the annulata Zone. He identified the specimen (MfN, Pl. 5.36, Figs. 3,4) so because it had biconvex growth-lines, faintly ribbed inner whorls, and a ventral band. Slight differences between its ventral band and that of Oxy. sedgwickii caused Lange to separate this specimen from the others. The suture was not described, and is not visible now. Lange used this specimen to suggest that Oxyclymenia was already present in the annulata Zone. Lange argued that Oxyclymenia could not have had Clymenia as its antecedent since its first occurrence preceded that of Clymenia; nor Platyclymenia, since they were present side by side. The first conclusion can be readily understood, the second less so. Lack of knowledge of the suture makes any identification of this specimen questionable, but it is probably a Platyclymenia.

Returning to the two other species, elegantula and lamellosa, which Schindewolf included in synonymy with Oxy. subundulata, it is difficult either to agree or disagree with Schindewolf because the type specimens are small.

Oxyclymenia subundulata var. elegantula Wedekind (1914, p. 52, pl. 2, figs. 10a,b, proposed as the lectotype) was distinguished by its tabulate venter. Wedekind considered that subundulata had a rounded venter (see pl. IV, fig. 4c); this opinion is impossible to justify because Wedekind did not section the lectotype of subundulata, and it has weathered outer whorls, thus obscuring the true nature of its venter. Growth-lines on the lectotype of elegantula at a diameter of 34mm are biconvex, slightly prorsiradiate, bunched into groups of 4 or 5 and widely spaced, numbering 1.8 per mm. Wedekind collected the specimen from the lower Clymenia Stufe at Hövel and it appears to resemble closely the large specimen from the same locality figured by Lange (see above).

Schmidt (1924, pl. 7, figs. 7,a) figured a specimen which he interpreted as Oxy. undulata var. elegantula. It too has a tabulate venter but bears little other similarity to the lectotype of elegantula. The whorl section is far broader than in Wedekind's figure (although Wedekind did not section the specimen from which he drew his cross-section). The growth-lines (Pl. 5.24, Figs. 7,8) are biconvex and bunch to form ribs, and at a diameter of ca 40mm number 7 per mm. This specimen is compared with Kosmo. inaequistrata below.

Oxyclymenia lamellosa Wedekind 1914 is impossible to define. The small specimen figured by Wedekind is believed to be lost. The species was discussed above in the introduction to this genus, where it was considered as a nomen dubium.

Both Nalivkina (1947) and Kullmann (1960) assigned specimens to this species solely on the basis of shell form. The examples they illustrated are all poorly preserved.

Petter (1960) illustrated a number of specimens which she assigned to Kosmo. sedgwickii. Three of these at least (pl. VII, figs. 1a,b; 5,a; 10) are juveniles and cannot be identified specifically. The others (pl. VI, figs. 1,a; 3,a; 6,a; 10,a,b), with closely spaced bunched growth-lines, low ribs, and a tabulate venter, are closest to Kosmo. elegantula sensu Schmidt.

Kosmo. subundulata, the earliest known example of the genus, has been considered as the ancestral species.

Horizon and distribution: The species is known with certainty only from the Sauerland, Kellerwald and Oberfranken, occurring in the Clymenia and lower Wocklumeria Stufen.

Kosmoclymenia inaequistriata (Münster 1832)

Pl. 5.21, Figs. 1,2,4,5,7; 5.23, Fig. 10; 5.24, Figs. 1,2,7-13, 17,18; 5.29, Figs. 1-3; Textfigs. 5.27F,G.

(?)	1832	Ammonites inaequistriatus Münster - von Buch, p. 178, pl. II, figs. 10,11.
*	1832	Planulites inaequistriatus sp. nov. - Münster, p. 10, pl. I, figs. 4a-c.
	1834	Clymenia inaequistriata Münster - Münster, p. 72, pl. II, figs. 2a-c (copy of Münster 1832).
	1843	Clymenia inaequistriata Münster - Münster, p. 8, pl. IIa, figs. 4a-c, (copy of Münster 1832).
vnon.	1863	Clymenia undulata Münster - Gümbel, p. 139, pl. XVII, figs. 4a-c only.
p.	1923a	Oxyclymenia undulata Münster - Schindewolf, p. 468.
p.v	1923a	Oxyclymenia subundulata Wedekind - Schindewolf, p. 471, pl. XVIII, figs. 8,9.
v	1924	Oxyclymenia elegantula Wedekind - Schmidt, p. 135, pl. 7, figs. 7,a, textfig. 5i.
?	1929	Oxyclymenia subundulata Wedekind - Lange, p. 121, pl. 3, figs. 37,a.

Type material: A neotype, SM H10376, collected by Münster from Schübelhammer, Oberfranken, is proposed here.
Remarks: The type series comprised two specimens (Münster 1833). The specimen (BSP AS VII 597) which Gümbel figured (1863, pl. XVII, figs. 4a-c) may be one of these, but because it does not resemble Münster's (1832) figure of the species it is rejected, and a neotype (which bears closer resemblance to Münster's figure) has been chosen.
Diagnosis: Species of Kosmoclymenia with fine closely spaced biconvex prorsiradiate growth-lines, numbering 10 per mm at a diameter of 30mm and a ratio U/D of ca 0.42. Periodically these are bunched to give the impression of very low ribs, numbering ca 80 per whorl.

Description: The neotype SM H10376 (Pl. 5.24, Figs. 9-11) is described; SM H10377 (Pl. 5.23, Figs. 3,4) is briefly mentioned and may represent the inner whorls of this species. Two specimens figured by Schindewolf (1923a) as <u>subundulata</u> are also discussed, and two specimens from the Sauerland are used to illustrate the ventral ornament.

The shell coiling is evolute with a whorl section which is circular at early diameters, but by a diameter of 20mm has become compressed. Textfig. 5.27G illustrates the change in successive whorls from a circular whorl section (D = ca 10mm) to compressed (D = ca 14mm), to compressed with converging flattened flanks and flattened venter (D = ca 22mm), to oval (D = 44mm) and finally a quarter of a whorl later at a diameter of 55mm there is a tabulate venter bounded by shallow grooves.

Growth-lines are clearly visible on only the last whorl of the neotype. Here (Textfig. 5.27F) they are prorsiradiate, biconvex with a broad sinus occupying most of the flank. The course of individual growth-lines cannot be followed across the margins of the ventral band, but they are typically semicircular, bounded by two lines. If SM H10377 is indeed a juvenile of this species the growth-lines on earlier whorls have a much broader flank sinus, and a narrower more pointed ventro-lateral salient. There are 17 semicircular spine bases on this specimen in the half whorl prior to a diameter of 20mm, suggesting that this specimen had a continuous flare projecting from the ventro-lateral shoulder (see also Pl. 5.21, Figs. 2,7).

The neotype has 10 growth-lines per millimetre at a diameter of 30mm. These are bunched into groups of approximately six, forming low ribs. The suture is strongly recrystallised, but is of the normal <u>Kosmoclymenia</u>-type.

Two specimens (HU P82.8, Pl. 5.21, Figs. 1,2; HU P82.10, Pl. 5.21, Figs. 4,5,7, Pl. 5.23, Fig. 10), show the ventral ornament particularly clearly. On P82.8 the growth-lines are bunched, and corresponding to each group of growth-lines is a short backwardly directed spine, extending from the ventro-lateral shoulder and joined to the previous spine to form a continuous flare. The flare is formed by the extension of shell material at the ventro-lateral shoulder. Periodically apertural extensions do notextend to the full height of the previous part of the flare, and are then overlapped by the next part. Weak plications can be seen on the most orad part of the internal mould of the body chamber preserved. Such plications are also visible on HU P82.10, where they also extend across the venter (Fig. 5). Where the flare is preserved it can be seen that it is broken up into a series of low spines, creating a serrate margin.

Dimensions:

	D	U	WW	WH
Neotype, SM H10376	56.4	23.3	14.4	19.1
	45	18.8	11.3	14.6
	32	13.2	9.3	11
	21.2	8.8	7.2	7.7
SM H10377	15.1	6.6	6.7	5.3
BSP AS VII 597	26.5	11.8	7.1	8.7
Mbg 3135, figured by Schindewolf 1923a, pl.XVIII, fig. 8.	47	19.8	9.5	15.9
MfN, figured by Schindewolf 1923a, pl.XVIII, fig.9.	50.2	21.8	10.5	16.2
MfN c541, figured by Schmidt 1924, pl.7, fig. 7,a.	56.4	25	13.2	17

Discussion: This specific name was first used by von Buch (1832) who described Ammonites inaequistriatus using material from Schübelhammer, sent to him by Münster. The description is ambiguous, and the figure only a sketch which shows a suture with a well developed ventro-lateral lobe, unlike Kosmoclymenia. In the absence of any type material in Berlin _Amm._ _inaequistriatus_ is treated as a _nomen dubium_.

In the same year, in a work whose publication post-dated that of von Buch (see the argument under _Gon._ (_Gon._) _speciosa_, above) Münster described "_Planulites_ _inaequistriatus_ nobis" (_sic_). This is treated as the first vaild usage of the name, and not as synonymous with _inaequistriatus_ von Buch, since that taxon was described in a different genus.

The specimen figured by Münster (1832) had a diameter of 90mm (pl. I) and for this reason the example figured by Gümbel (1863, pl. XVII, fig. 4), described below, cannot be accepted as the original. No author since Gümbel has used the specific name, and even he did not describe the examples in Munich. Schindewolf (1923a) included _Cl._ _inaequistriata_ in synonymy with _Oxy._ _undulata_ without justification, and described and illustrated two specimens as _subundulata_. They are poorly preserved, being flattened and stylolitised in parts, but, or because, they are ribbed, they are referred to _Kosmo._ _inaequistriata_. The smaller one (Mbg 3135, Pl. 5.24, Figs. 12,13) has closely spaced growth-lines, numbering 3 per mm at a diameter of ca 35mm, and a flank to venter growth-line ratio of 12:1. The larger specimen (MfN; Pl. 5.24, Figs. 17,18) shows growth-lines which have modified in shape in the same way as those on the specimen from Ense described above. At a diameter of 45mm there are weathered remains of 4 ribs over the ventro-lateral shoulder. The venter at this stage is tabulate.

In 1924 (p. 135, pl. 7, figs. 7,a, textfig. 5i) Schmidt described a specimen (MfN c541) collected by Denckmann from Dasberg. This (Pl. 5.24, Figs. 7,8) has a shell shape similar to _Kosmo._ _inaequistriata_, but has deep grooves delimiting the tabulate venter and fewer, more prominent growth-lines. They number 7 per mm at a diameter of 26mm, and have the same biconvex course as Kosmo. inaequistriata. Gümbel's specimen (BSP AS VII 539) of Cl. inaequistriata (pl. XVII, figs. 4a-c) from Schübelhammer, Oberfranken (Pl. 5.24, Figs. 1,2) resembles MfN c541, as does another unfigured specimen from the same locality (BSP AS VII 542). Further examples with a similar form were illustrated by Petter (1960, pl. VI, figs. 1,a, 3,a) as Kosmo. sedgwickii.

The precise stratigraphic position is not known for any of these specimens. The morphological difference between them and the neotype of Kosmo. inaequistriata is not considered sufficient to warrant the use of a different taxonomic name.

Comparisons: Growth-lines are prorsiradiate as in Kosmo. subundulata, but in that species they are not bunched. The ratio U/D is consistently higher, also (Textfig. 5.28a). Kosmo. sublaevis does not develop a ventral band, nor flares, and it has a stouter whorl section.

Horizon and distribution: The horizon of the neotype from Schübelhammer, Oberfranken is unknown, but is probably in the Clymenia Stufe. Kosmo. inaequistriata is known from the Sauerland, Oberfranken (W. Germany) and Algeria. Its stratigraphic position is also presumed to be in the Clymenia Stufe.

Kosmoclymenia sp. a

Pl. 5.24, Fig. 6

Material: A single specimen (BSP 1886 III 27) from Dzikowiec, Poland.

Diagnosis: Kosmoclymenia with ventral band, compressed quadrate whorl section with flattened flanks and few convexo-concave growth-lines, spaced at a frequency of two per millimetre.

Description: Little need be added to this brief diagnosis of a single, but distinctive, specimen. The fine, widely spaced growth-lines characterise this species. The venter has relatively few semicircular growth-line sinuses, numbering 9 in the half whorl prior to a diameter of 37mm.

Dimensions:

	D	U	WW	WH
BSP 1886 III 27 Pl.5.24,Figs.5,6.	36.8	16.7	9.2	11.7

Remarks: This specimen is included to demonstrate the breadth of variation within this genus. It is included within Group I, because of its ventral ornament, although growth-lines do not have a biconvex course over the flanks, unlike the other species in this group.

<u>Kosmoclymenia</u> Group II

<u>Kosmoclymenia</u> (Group II) is poorly represented in the museum collections. Several species certainly exist; the two named species are described below but insufficient material is available to propose new ones formally. Several specimens are illustrated to demonstrate the variability within the group. <u>Kosmoclymenia carinata</u> and <u>coronata</u> are known from few, poorly preserved specimens and the information available about them is discussed.

<u>Kosmoclymenia coronata</u> (Schmidt 1924)

The type-series of <u>Kosmoclymenia coronata</u> (Schmidt 1924) consisted of 16 specimens, two of which are currently housed in Berlin. The figured specimen (1924, pl. 7, fig. 6) from Dasberg is illustrated here (Pl. 5.25, Figs. 12,13) and proposed as the lectotype. Schmidt defined his variety coronata by its indications of ribs on the umbilical shoulders. These can be clearly seen in Fig. 12, as are faint nodes at the ventro-lateral shoulder. The lectotype is small, reaching only 17mm in diameter; its mature form is therefore unknown. The whorl section is quadrate, with a rounded venter. Growth-lines are rursiradiate, sickle-shaped over the flanks rather than biconvex because the ventrad salient is actually centred on the venter. The sinus occupies most of the flank. No indications of spines can be seen on the ventral area.

Kosmoclymenia carinata (Ansted 1838)

Kosmoclymenia carinata (Ansted 1838) is also poorly known and based on a small specimen (SM H4011), which is figured here (Pl. 5.25, Figs. 2,3). This is distorted and attains a maximum diameter of ca 35mm. The whorl section is slightly compressed and the venter rounded. Growth-lines are biconvex, radial and continue from the flank over the venter. No spines are evident.

Four unnamed "species" are newly recognised, referred to by the letter d, e, f, g, and these fall into two groups d,e and f,g. The first group has strongly rursiradiate growth-lines and an oval whorl section; in the second the growth-lines are only slightly rursiradiate and the whorl section quadrate.

An example (No. 80, species d) from the Münster Collection at the University of Erlangen-Nürnberg (Pl. 5.25, Figs. 15,16, Textfig. 5.26F) has a very smooth shell with barely visible growth-lines, particularly over the venter. These are rursiradiate and slightly biconvex with a deep semicircular ventral sinus (Fig. 16). Growth-lines occur in equal numbers on the flanks and the venter, and the frequency per millimetre on the venter at a diameter of

20mm. Rugose lirae with a spacing of 9 per mm run transversely across the venter.

Another small but distinctive specimen (species _e_, SM H10399, Münster Collection, Schübelhammer) has widely spaced rursiradiate concavo-convex growth-lines on the flanks (Pl. 5.25, Figs. 7-9, Textfig. 5.26G). The whorl section is oval.

Three specimens from Dzikowiec (all in the MfN) fall into another group with less rursiradiate growth-lines. Species _f_, illustrated in Pl. 5.25, Figs. 1,2, has radial biconvex growth-lines, and is similar in morphology to _Kosmo_. _sublaevis_, except that it lacks the two lines delimiting the venter. The Polish specimen also has faint ribs on the umbilical shoulder, and spiral lines on the last flank of the whorl. Species _g_, represented by two specimens (MfN c594, Pl. 5.25, Figs. 10,11; MfN Pl. 5.27, Figs. 19,20) is evolute (umbilical width is greater than 50% of the diameter) with a quadrate whorl section and has slightly rursiradiate, biconvex growth-lines. Most notably a tabulate venter is developed at a diameter of 65mm (Figs. 19,20), bounded by two pronounced ventro-lateral grooves, resulting in a low blunt keel.

Dimensions:

	D	U	WW	WH
Pl.5.25,Figs.1,2 _Kosmo_. _carinata_ holotype, SM H4011	34.1	18.0	7.5	8.5
Pl.5.25,Figs.12,13 _Kosmo_. _coronata_	17.7	8.6	ca 4.2	5.0
Pl.5.25,Figs.15,16 Univ. Erl-Nürnberg No. 80, _Kosmo_. sp _a_	24.4 18.6	12.1 9.3	- 4.5	7.6 5.1
Pl.5.25,Figs.7-9 SM H10399, _Kosmo_. sp. _e_	23.9 18.1	13.0 10.1	4.7 4.0	6.0 4.7
Pl.5.25,Figs.1,2 MfN, _Kosmo_. sp. _f_	38.5	17.5	ca 8	11.3

	D	U	WW	WH
Pl.5.25,Figs.10,11 MfN,c594, Kosmo. sp. g	52.8	26.9	12.5	15.3
Pl.5.27,Figs.19,20 Kosmo. sp. g	65	32.8	-	17.8

Planulites planorbiformis Münster 1832 (p. 8, pl. II, figs. 1a-c) could be interpreted as belonging to this species group. The original figure shows the species to have serpenticonic shell, with a compressed whorl section. The umbilicus is wide (U/D = 0.52) and shallow; the growth-lines are concave over the flanks up to a diameter of 30mm, and then biconvex, with a ventral sinus. The suture is of Kosmoclymenia-type. Richter (1848, pl.III, figs. 86-8) and, later, Schmidt (1924) interpreted this species as a Kosmoclymenia synonymous (p. 169) with Oxyclymenia linearis (Münster). Schmidt did not say whether he considered this species to have a ventral band. Gümbel (1863, p. 160) stated that Münster had figured the original specimen inaccurately. In his figure (pl. XXI, figs. 6a-e) Gümbel shows a widely umbilicate form, but with straight radial growth-lines, a reniform whorl section, and a Cycloclymenia suture. Gümbel was not certain that this was Münster's original as he could see no suture prior to preparing one.

It would be tempting to ignore Gümbel's interpretation of Cl. planorbiformis, and to accept Münster's description and figure at face value, except that the only well labelled specimen known to me (SM H10375) is undoubtedly a Cycloclymenia, but with a compressed whorl section and shell shape resembling Münster's figure. Therefore interpretation of the specific name will be based on this specimen, and Cycloclymenia clymenioides is recognised as a junior subjective synonym of it. This genus has long been believed to occur in the lower Clymenia Stufe (Schindewolf), but preparation of conodonts from the matrix of the proposed neotype of Cyclo. planorbiformis (SM H10375) and the proposed lectotype of Cyclo. clymeniodes (UEN) gave an assemblage dated (by Prof. W. Ziegler) as marginifera Zone, which lies in the sandbergeri Zone. This age places Cycloclymenia much nearer in time to its relatives Prolobites and Clymenoceras.

Kosmoclymenia sublaevis (Münster 1832)

Pl. 5.20, Figs. 3,4, Pl. 5.25, Figs. 5,6, Textfigs. 5.24C-E

?v* 1832 Planulites sublaevis sp. nov. - Münster, p. 10, pl. II, figs. 3a-b.

1834 Clymenia sublaevis Münster - Münster, p. 72, pl. I, figs. 7a-b (copy of Münster 1832).

1842 Clymenia sublaevis Münster - Münster, p. 124,

1843 Clymenia sublaevis Münster - Münster, p. 6, pl. IIa, figs. 3a-b (copy of Münster 1832).

p 1863 Clymenia undulata Münster - Gümbel, p. 120, pl. XVII, figs. 2a-c (? refiguring of the specimen figured by Münster).

? 1914 Oxyclymenia undulata var. sublaevis Münster - Wedekind p. 51.

Type material: A specimen from Schübelhammer, BSP AS VII 540, is proposed as the lectotype.

Diagnosis: Kosmoclymenia with rounded venter. Growth-lines are moderately biconvex, radial, and all run over the weak ventral band.

Description: Two specimens have been examined; the lectotype (BSP AS VII 540, Pl. 5.25, Figs. 5,6) and another specimen, labelled as Cl. lineata in the Münster Collection at the British Museum (NH) (BM 81830, Pl. 5.20, Figs. 3,4).

The lectotype is evolute, umbilical width increasing to 45% at the maximum diameter of 45mm. Early whorls appear to have a rounded cross-section, but flattened flanks and an oval cross-section are developed by a diameter of 35mm.

Growth-lines, although present on the lectotype, are weathered and can be more clearly seen on BM 81830. These are radial, bi-convex and expressed as raised lirae. The salient and sinus on the dorsad part of the flank is broad and shallow, the ventro-lateral salient is narrower and more strongly curved. A sinus is formed on the venter (Fig. 3) which is bounded by two lines. The flank to venter growth-line ratio is 1:1. The growth-lines are bunched. This is caused by a variation in the spacing, ten closely spaced lirae being followed by 4 or 5 which are more widely spaced. This bunching is also visible on the venter. The suture has not been observed.

Dimensions:

	D	U	WW	WH
Lectotype, BSP AS VII 540, Pl.5.25, Figs.5,6.	41.2 33.5	18.2 14.4	12.4 10.3	15 11.5
BM 81830, Pl.5.20, Figs.3,4.	33.8		ca 8	12

Discussion: Münster (1833, 1842) listed at least four specimens as belonging to this species, and it is questionable whether the lectotype corresponds exactly with the figures given by Münster and Gümbel. However, it does agree with Münster's description (1832, p.10) which was, "... smooth shell seldom showing striations... and rounded venter". This was amplified later (Münster 1842, p. 124) where the diagnostic characteristics of almost radial growth-lines with a smooth venter were emphasised, contrasting with <u>Kosmo</u>. <u>undulata</u>, which had sickle-shaped growth-lines with a deep pocket shaped sinus, on a flattened venter. The caption to Münster's figure (1832, p. 37) refers to "<u>Plan</u>. <u>laevis</u>", but this is taken as an error for <u>sublaevis</u>, since that name appears twice elsewhere in the text (pp. 10, 35).

Gümbel's (1863, pl. XVII, fig. 25) illustration of a specimen terminated by a septal face may be an elaboration or be based on another specimen, now lost. The growth-lines (1863, fig. 2c) closely resemble those on the lectotype. Both Gümbel and Münster show far fewer growth-lines on inner whorls than on the last whorl; growth-lines are only visible on the last whorl preserved on the lectotype. Earlier they may either have been weathered away, or be much weaker.

Wedekind (1914) recognised the usefulness of this name for a variety with weak growth-lines. However, this description could be applied to several species. I have not seen any of his material nor did he provide a figure, so it is not possible to include his reference in the synonymy with certainty.

Three other specimens are figured which closely resemble Kosmo. sublaevis. One, SM H4011 (Pl. 5.25, Figs. 3,4) is the holotype (recognised here) of Endosiphonites carinatus Ansted 1838 from Landlake, Cornwall. This is a small distorted specimen on which the venter is not well preserved, it is not, therefore, placed in synonymy with Kosmo. sublaevis. The shape of the growth-lines over the flank and venter appear similar.

An unnumbered specimen housed at Krefeld (NWGL; Pl. 5.22, Figs. 2-4, Textfig. 5.26E) from the Ostprovinzial Steinbruch, Drewer, Sauerland, is identified as Kosmo. aff. sublaevis. This has a similar shell shape and growth-line course over the flanks. However, the growth-lines are more closely spaced (12 per mm on the venter at a diameter of 40mm, compared with 8 per mm at a similar diameter on Kosmo. sublaevis). Also, by a diameter of 40mm a tabulate venter has been developed, and there are no lines around the ventro-lateral shoulder.

A silicified internal mould from Bilsteinhöhle (DK 81D 6403.2; Textfigs. 5.24C-E) was dissected to show the sutural ontogeny of Kosmoclymenia. A sharp lateral lobe was found already to be present at a diameter of 4mm.

Dimensions:

	D	U	WW	WH
SM H4011	34.5			
NWGL	50.8	19.6	ca14	19.2
	34.1	13.5	12.4	12.5

Horizon and distribution: The lectotype came from Schübelhammer, Oberfranken; its horizon is unknown, and this may be in either the Clymenia or Wocklumeria Stufen. Wedekind (1914) recorded examples from the Sauerland.

Kosmoclymenia wocklumeri (Wedekind 1914)

Pl. 5.25, Figs. 14,17

*	1914	Oxyclymenia wocklumeri sp. nov. - Wedekind, p. 53, pl. 7, fig. 6.
v?p	1923a	Oxyclymenia linearis Münster - Schindewolf, p. 472, non pl. XVIII, fig. 7.
v	1924	Oxyclymenia undulata var. wocklumeri Wedekind - Schmidt, p. 135, textfig. 5e.
?	1929	Oxyclymenia linearis (Münster) - Lange, p. 126.
	1937a	Oxyclymenia wocklumeri Wedekind - Schindewolf, p. 37.

Type material: The specimen figured by Wedekind (1914, pl. 7, fig. 6) from Burg, Balve, Sauerland, now housed at Göttingen, is proposed as the lectotype.

Diagnosis: Evolute smooth shelled Kosmoclymenia. Early whorls are circular, but after a diameter of ca 50mm the flanks become flattened and converging, the venter tabulate and the umbilical shoulder distinct. The barely visible growth-lines change from being rursiradiate, concavo-convex over the flanks to radial and biconvex at the same point.

Description: Little can be added to the diagnosis. Schmidt (1924) figured the characteristic whorl cross-sectional shape. This diagram, based on a specimen (MfN) from Oberrödinghausen, is at natural size. BM 81854 (Münster Collection) is recognised to belong to this species, by its weak rursiradiate convexo-concave growth-lines (Pl. 5.25, Figs. 17).

Dimensions:

	D	U	WW	WH
Wedekind 1914, p.53	104	50	30	23

Discussion: Schindewolf (1923a) failed to recognise this species at Kirch-Gattendorf, or in the Münster Collections. Lange (1929) interpreted this species broadly and included it with Oxy. linearis Münster, using Schindewolf's interpretation of that species. Examination of specimens of Kosmo. linearis from Kirch-Gattendorf in the Schindewolf Collection at Marburg/Berlin shows them to have remains of ventral spines (Pl. 5.23, Figs. 1,2, Pl. 5.24, Figs. 15, 20). Therefore Lange was wrong to synonymise Kosmo. linearis with wocklumeri.

Horizon and distribution: The species is known from Cornwall (England), Sauerland and Oberfranken (W. Germany). Schindewolf (1937a) recorded it from the Hangenberg Schiefer and Beds 1-11 at Oberrödinghausen, that is in the upper Wocklumeria Stufe.

Kosmoclymenia Group III

Kosmoclymenia bisulcata (Münster 1840)

Pl. 5.26, Figs. 9.12.13. Textfigs. 5.29A-C

v*	1840	*Clymenia bisulcata* sp. nov. - Münster, p. 93, pl. XV, figs. 6a-b.
(?)	1842	*Clymenia bisulcata* Münster - Münster, p. 125.
v	1863	*Clymenia undulata* Münster - Gümbel, p. 140, pl. XVIII, figs. 12a-e, (refiguring of the lectotype).
non.	1902	*Clymenia bisulcata* Münster - Frech, p. 34, pl. II(I), figs. 12a-c.
vnon.	1923a	*Oxyclymenia bisulcata* Münster - Schindewolf, p. 474, pl. XVIII, fig. 6.
non	1924	*Oxyclymenia bisulcata* Münster - Schmidt, p. 135.
?	1929	*Oxyclymenia bisulcata* Münster - Lange, p. 125.
non	1960	*Kosmoclymenia bisulcata* (Münster) - Selwood, p. 27, fig. 2.
p.	1960	*Kosmoclymenia bisulcata* (Münster) - Petter, p. 38, pl. IV, figs. 2,a, 7,a, (non figs. 8,a) textfig. 4G.
?	1965	*Kosmoclymenia bisulcata* (Münster) - Sun and Shen, p. 54, pl. II, figs. 10a,b, textfig. 12.
non.	1979	*Kosmoclymenia bisulcata* (Münster) - Korn, textfig. 2e (= *Kosmo*. cf. *similis*).
p.	1981	*Kosmoclymenia bisulcata* (Münster) - Ruan, p. 125, pl. 31, figs. 15,16, ?figs. 10-14, fig. 92.

Type material: BSP AS VII 535, from Schübelhammer, Oberfranken, is proposed as the lectotype.

Diagnosis: *Kosmoclymenia* with prominent rounded keel bounded by ventro-lateral grooves, and strongly biconvex growth-lines.

Description: Three specimens have been examined: the lectotype BSP AS VII 535; HU P82.12, collected from scree at Reigern, and a specimen labelled as from South Petherwin, in the Wiesbaden Museum. These last two specimens differ in detail from the lectotype and are referred to *Kosmo*. aff. *bisulcata*.

The lectotype (Pl. 5.26, Figs. 10,11) has poorly preserved inner whorls. No cross-section has been prepared but they appear evolute with a rounded to oval shape. The last whorl preserved is compressed with flattened flanks and a rounded ventral shoulder, which is delimited by two shallow grooves at the margins of a high rounded keel. The keel is first present at a diameter of 35mm though here the venter is filed and thus it may have developed earlier.

Well preserved growth-lines are visible only at a diameter of 45mm, where they are strongly biconvex. The dorsad salient is the wider, and the midflank sinus is centred three-quarters of the distance from the umbilical seam to the base of the keel. The other salient runs forward over the ventro-lateral shoulder and there is a deep sinus over the keel. The polished suture is of normal Kosmoclymenia-type.

The specimen from Reigern (Pl. 5.26, Figs. 14-16) shows inner whorls lacking a keel (Textfig. 5.29B) and a lower less prominent keel on the last whorl at a diameter comparable with the lectotype. The growth-lines are of similar shape (Textfigs. 5.29A,C) although the salients are less prominent.

The smaller specimen from South Petherwin (Pl. 5.24, Figs. 3,4) also has less strongly biconvex growth-lines, but there is a hint (Fig. 4) of a rounded keel at a diameter of 25mm. After this the venter is damaged.

Dimensions:

	D	U	WW	WH
Lectotype, BSP AS VII 535	43.3	19.8	9.0	14.2
HU P82.12	ca50		11.5	15.2
Wsb	27.3	12.3	ca 6	3.0

Discussion: This seems a rare, although widely distributed, species. Besides the three specimens described here only three others are known to me, two from Algeria (Petter 1960) and one from Kweichow, s.w. China (Sun and Shen 1965). Widespread reference has been made to the species (Schindewolf 1923a, 1937a, Schmidt 1924, Selwood 1960) but this is erroneous, as the specimens described there all have wide tabulate venters, bounded by ventrolateral furrows. These are discussed below under Kosmoclymenia (Group IV).

Gümbel (1863, p. 140) reported three Münster specimens which may perhaps explain how he was able to draw a cross-section (pl. XVIII, fig. 12e), and growth-lines. These, however, were prorsiradiate and do not agree with either Münster's figure, or what is visible on the lectotype.

The single specimen described by Sun and Shen (1965) has a ventral keel which is much narrower than that of the lectotype, and is referred to Kosmo. aff. bisulcata.

Comparisons: Protoxyclymenia serpentina has similar growth-lines to Kosmo. bisulcata, but develops its less prominent keel much later. Also its suture is different. Kosmoclymenia galeata (Wedekind 1914) has a more oxyconic shell form, with a pointed venter rather than a keel.

Horizon and distribution: The species is known from Oberfranken and Sauerland (W. Germany), Cornwall (England) and Souara Valley (Algeria). The precise horizon is unknown, but Petter (1960) reported her specimens from the Clymenia Stufe, or its upper boundary, and the limited exposure at Reigern, part of which is of Wocklumeria Stufe age, suggests that the specimen from there is either of this age, or from the upper Clymenia Stufe.

Kosmoclymenia colubrina (Lange 1929)

Pl. 5.26, Figs. 1-5, Pl. 5.30, Figs. 16,17, Textfigs. 5.24F,G

v* 1929 Oxyclymenia bisulcata var. colubrina nov. - Lange, p. 125, pl. 3, fig. 39, textfig. 39.

Type material: A holotype (MfN) from Dasberg, Sauerland, was designated by Lange (1929).

Diagnosis: Kosmoclymenia with compressed whorl section and flattened venter in early whorls, which develops into a quadrate keel, the internal mould of which is noded. Faint plicate ribs are present at all stages.

Description: Three museum specimens are described here; the holotype (Pl. 5.26, Figs. 2,3) and two specimens from the Kellerwald (Pl. 5.26, Figs. 1,4,5). All are housed in the Museum für Naturkunde, Berlin. Also described is a single specimen (KW 2081), collected from Dasberg (Pl. 5.30, Figs. 16,17).

The holotype is well preserved, although slightly distorted. It shows smooth, rounded inner whorls with faint plicate ribs on the dorsad half of the flanks. At a diameter of approximately 15mm the growth-lines are visible as raised lirae and are rursiradiate. One whorl later, at a diameter of 25mm, the course of the growth-lines can be seen, still rursiradiate but clearly biconvex, with a sinus over the venter. At this point the venter is tabulate but during the last half whorl preserved a high keel develops (Fig. 3), which at a diameter of 44mm is quadrate and bounded by two grooves. The internal mould of the venter is noded, and presumably the venter itself was too. The shell is missing from the flanks of the last half whorl (Fig. 3), where there are weak, plicate ribs running parallel to the biconvex growth-lines, which are stronger than in earlier whorls. At a diameter of 32mm there is a constriction with a deep concave course. The suture was not seen.

The specimen in Pl. 5.26, Figs. 4,5, is smaller than the holotype and lacks a keel. It does, however, show smooth inner whorls, lirate biconvex growth-lines at a diameter of 20mm and a tabulate venter. Another specimen (Pl. 5.26, Fig. 7) differs in having a smoother shell, lacking raised lirate growth-lines, but is similar in other respects. Its stratigraphic position is unknown, and it is not separated taxonomically.

The modification of the growth-line shape on the body chamber can clearly be seen on KW 2081 (Pl. 5.30, Figs. 16,17). Here the body chamber is preserved complete with shell, the venter is tabulate, but the ventro-lateral groove is less marked than on the internal mould of the holotype. Early growth-lines (Textfig. 5.24G) are biconvex, and lirate, bunched into groups of 3 or 4, separated by areas of relatively smoother shell. On the body chamber, at diameters greater than 35mm where ventro-lateral grooves begin to develop, the growth-lines become much finer, more closely spaced, and have more prominent ventro-lateral and lateral salients (Textfig. 5.24F). Weak ribs are present, just as on the internal mould of the holotype.

Dimensions:

	D	U	WW	WH
Holotype Pl.5.26, Figs.2-4, MfN	43.9 33.9	21.5 17.6	ca 9.8 6.2	12.5 9.8
MfN, Pl.5.26, Figs.4,5.	26.5	12.5	5.5	8.5
MfN, Pl.5.26, Fig.1.	19.5	10.1	3.5	5.4
KW 2081	39.5	13.4	-	10.7

Discussion: This species is distinguished from others in the group by its prominent tabulate venter. The specimen in Figs. 4,5, was recognised by Schindewolf in 1925 as a new species and given the manuscript name *falcata*.

Horizon and distribution: The horizon of these species is known only as *Clymenia* Stufe. It has been collected in the Sauerland, Kellerwald and Oberfranken, and from Dzikowiec.

Kosmoclymenia sp. *h*

Pl. 5.26, Figs. 6-8, Textfigs. 5.29J-K

One unnamed species (referred to as species *h*) which has been recognised within this group, is represented by two specimens: one from Dzikowiec, Poland, and the other from Schübelhammer, Oberfranken.

The Polish specimen is evolute with an almost smooth shell. Inner whorls show faint ribbing, and the whorl section is compressed. At a diameter of ca 20mm a raised tabulate venter is developed (Fig. 7). The growth-lines are strongly biconvex and radial.

The smaller specimen collected by Münster (SM H10400, Pl. 5.26, Fig. 6, Textfigs. 5.29J,K) resembles species *h* and is referred to as *Kosmo*. aff. species *h*. It is smaller, has a smooth shell, tabulate venter and compressed whorl section but the two salients of the radial biconvex growth-lines are of equal size, unlike the Polish specimen. This specimen could, arguably, represent the inner whorls of *Pro. serpentina*.

In neither of the above specimens has the suture been seen, nor is the stratigraphic horizon known.

Dimensions:

	D	U	WW	WH
MfN Pl.5.26,Figs.7,8	24.5	12.4	5.2	6.9
SM H10400, Pl.5.26,	23.6	11	4.3	5.2
Fig.6.	18.3	9.6	4.0	ca5.0

Kosmoclymenia Group IV

Group IV is discussed primarily to clear up any ambiguity in the interpretation of Kosmo. bisulcata, but there is also a question of whether any other Münster species should be included within it. There are two such species in contention: semistriata and similis. Münster did not figure them, but his descriptions are paraphrased below:

> Cl. semistriata Münster 1839, p. 11, Schübelhammer. Only the outer whorl is sharply striated, the inner whorls are smooth. The striations are joined in a sharp chevron on the venter. It is discoidal and little involute. The pointed lateral lobe is small.

> Cl. similis Münster 1839, p. 11. From the grey transitional limestone of Gattendorf near Hof. A fine striation of the shell runs straight over the whorls, as in Cl. planorbiformis. The last whorl is compressed and the venter sharply curved. The whorls increase rapidly in width.

Gümbel (1863) discussed these nominal species and figured two specimens which he interpreted as Münster's originals, selected from a number of specimens in the Munich Collection.

One of these (pl. XVII, fig. 6), Cl. semistriata, is illustrated here (BSP AS VII 552, Pl. 5.27, Figs. 16,17). The specimen resembles Münster's brief description reasonably well, though no ornament is visible on the venter. It is proposed as the lectotype. The lack of additional material means that only a brief description can be given.

Evolute with smooth inner whorls, and slowly increasing whorl width, the body chamber shows almost concave growth-lines with a strong ventro-lateral salient and has a compressed flask-shaped section, with a tabulate venter. The internal mould shows shallow plicate ribs on the ventrad part of the flanks and ventral wrinkle-layer.

The nature of Cl. similis is less clear. Gümbel again selected what he considered to be Münster's original (pl. XVII, figs. 5a,b,d) from amongst several specimens. The specimen (BSP AS VII 544) labelled as Münster's original at Munich,cannot be said with certainty to be the one which Gümbel figured, since there are significant differences in the areas where he showed the shell to be absent, The specimen is illustrated here Pl. 5.26, Fig. 15, and is proposed as the lectotype. The growth-lines are the only diagnostic feature clearly visible on the lectotype; these are barely biconvex over the flank with a slight dorsad salient, and a very prominent ventro-lateral salient. The venter is damaged, but by a diameter of 18mm appears to be tabulate, bounded by ventro-lateral grooves.

In the collections at Cambridge there are two specimens (H10311,2) labelled by Münster as Cl. similis. Both are poorly preserved, the former may be Kosmo. wocklumeri and the other may be Kosmo. undulata or inaequistriata. Neither resembles the Munich specimen.

Two specimens from Langenaubach (Mbg unnumbered, Pl. 5.27, Figs. 1-5) are assigned to Kosmo. aff. similis. They have a similar shell morphology and growth-line course to Kosmo. similis. There are however, twice as many growth-lines on the specimen in Figs. 1,2 and the growth-lines on the specimen in Figs. 3-5 are alternately bunched and spread out, giving the appearance of ribbing. Both have dorso-lateral growth-line salients more strongly developed than on the lectotype of Kosmo. similis. Neither of the two specimens had spines or flares projecting from the venter, and a tabulate venter is developed on the larger specimen at a diameter of 17mm. The stratigraphic position of these two specimens is unknown.

At least four distinct species of this genus are known to me, but only from single specimens which cannot be accurately located stratigraphically. They are illustrated here to justify the inclusion of these species into a distinct morphological group, and to demonstrate the variation within it. Two of the species are alloted the Münster names defined above.

A common species in the lower Wocklumeria Stufe is the form which Schindewolf (1923a, pl. XVIII, fig. 6) interpreted as Oxy. bisulcata, which he collected from Bed 20, at Kirch-Gattendorf, an example of which (Mbg 3133) is described. This has a tabulate venter (Pl. 5.27, Figs. 13,14) and raised lirate growth-lines (Textfig. 5.29F). These are biconvex on the flank with a strong salient running forward across the ventro-lateral furrow, which delimits the venter. They reach furthest forwards on the vertical flanks of the venter, before running back to form a ventral sinus. The ratio of growth-lines on the flanks and venter is 1:1, and I do not therefore expect that spines were formed. At a diameter of 17mm there are approximately 40 widely spaced growth-lines in the previous quarter whorl, with a frequency of 12 in 5mm. This specimen is referred to Kosmo. similis. Both Münster's and Schindewolf's specimens were collected from the same locality.

Illustrated in Pl. 5.27, Fig. 6 is a specimen from Dzikowiec (MfN) with a similar morphology, but with twice as many growth-lines at comparable diameters. Specimens collected by Selwood (1960, GSM 87401, pl. 27, fig. 2) from Cornwall, and by Petter (e.g. 1960, pl. VI, figs. 8,a) from Algeria may have a similar shell morphology to the illustrated specimens, but growth-lines are not well preserved and the tabulate venter seems to be developed earlier.

A further distinctive specimen from Dzikowiec (species i, Pl. 5.27, Figs. 7-9) has growth lines which are only just biconvex, and a ventral band. Growth-line course across the flank is almost straight; there is a prominent ventro-lateral salient and a deep sinus over the venter (Textfig. 5.29G). Grooves delimiting the tabulate venter appear at a diameter of ca 25mm. Growth-lines number ca 40 per 5mm, at a diameter of 20mm, and the ratio of growth-lines on the flanks and venter is 6:1. Running between the ventral growth-line sinuses are the diverging lirae (Fig. 7) typical of specimens with ventral flares/spines.

Dimensions:

	D	U	WW	WH	R
Kosmo. semistriata lectotype, BSP AS VII 552, Pl.5.27, Figs.16,17.	15	8.5	5 3	7.2 2.7	13.2
Kosmo. similis lectotype, BSP AS VII 544, Pl.5.27, Figs.17,15.	23.5	10	-	7.8	
Mbg 3133, figured Schindewolf 1923a pl.XVIII,fig.6, Pl.5.27,Figs.13,14	23.9	11	ca40	6.9	
MfN, Pl.5.27,Figs. 5,6.	20.5	9		7.2	
Mbg, Pl.5.27,Figs. 1,2.	19.4 15	8.1 6.2	5.0 4.1	6.1 4.5	
Mbg, Pl.5.27,Figs. 3-5.	17.1	7.2	4.5	5.5	
MfN c595, Pl.5.27 Figs. 5-9.	29.0 22.5	12.7 9.5	7.2 6.2	9.4 7.6	

Family Cymaclymeniidae Hyatt 1884

Type genus: *Cymaclymenia* Hyatt 1884.
Diagnosis: Clymeniaceae with involute to subinvolute coiling, discoidal shell form, concavo-convex or biconvex growth-lines, and a suture comprising a weak ventro-lateral lobe, an asymmetric lateral lobe, and a dorsal lobe, at least, with no well defined umbilical lobe.

Description: Shell form varies little within this family. Ribbing concordant with the growth-lines is common, especially near the umbilicus, and some species develop ventro-lateral grooves. Sutural variation within the family consists of the addition of an internal lobe (within species all treated as *Genuclymenia*), or a shallow ventral lobe (*Kazakhoclymenia*).

Included genera:

Cymaclymenia	Hyatt 1884
Genuclymenia	Wedekind 1908
Kazakhoclymenia	Bogoslovskiy 1979b
Laganoclymenia	Bogoslovskiy 1979b

Remarks: The diagnosis of this family may seem ambiguous. In practice three genera (*Cymaclymenia*, *Kazakhoclymenia* and *Laganoclymenia*) are readily recognised by their distinctive box-shaped pointed lateral lobe. *Genuclymenia* is included here because it is considered to be ancestral to these three genera.

Horizon and distribution: *Genuclymenia* is known from the *delphinus* and *annulata* Zones of the Rheinische Schiefergebirge, Oberfranken, Kazakhstan and south eastern Australia. *Cymaclymenia* is widely known from the *Clymenia* and *Wocklumeria* Stufen of the eastern USA, western Europe, Urals, Kazakhstan, north Africa and Australia. *Kazakhoclymenia* is known from the *Clymenia* Stufe of Kazakhstan and *Laganoclymenia* from the *Wocklumeria* Stufe of the southern Urals.

Genus Genuclymenia Wedekind 1908

p 1908 Genuclymenia gen. nov. - Wedekind, p. 617, (rest: Hexaclymenia).
1914 Protoxyclymenia (Genuclymenia) Wedekind - Wedekind, p. 23.
p 1923a Genuclymenia Wedekind - Schindewolf, p. 432, (rest: (Protoxyclymenia).
1929 Genuclymenia Wedekind - Lange, p. 88.
p Protoxyclymenia Schindewolf - Lange, p. 120.
1953 Genuclymenia Wedekind - Nalivkina, p. 120.
1957 Genuclymenia Wedekind - Schindewolf, p. L44.

Type species: Genu. frechi Wedekind, by subsequent designation of Schindewolf, 1957.
Diagnosis: Cymaclymeniidae with subevolute coiling, and suture with asymmetric lateral lobe.

Description: The whorl section is compressed, but quadrate in some species, oval in others, with or without grooves running along the midflank. The venter is tabulate, flatly arched or narrow and rounded. Growth-lines are concave, concavo-convex, or biconvex, with a deep ventral salient. Ribbing, concordant with the growth-lines is common. The suture consists of a flat ventral saddle, asymmetric lateral lobe, dorsal lobe, and an umbilical lobe may be present to a greater or lesser degree.

Available species names include:

*	frechi	Wedekind 1908, p. 617, pl. XLIV, figs. 7,a.
	angelini	Wedekind 1908, p. 617, pl. XLIV, figs. 6,a.
	borni	Schindewolf 1923a, p. 433, pl. XVII, fig. 4.
	discoidalis	Wedekind 1908, p. 618, pl. XLIV, figs. 4,a.
	guembeli	Wedekind 1908, p. 618, pl. XLIV, figs. 5,a.
	karpinskii	Perna 1914, p. 81, pl. III, figs. 18a,b, 19, textfig. 8b.
	keepitensis	Jenkins 1968, p. 536, pl. 104, figs. 1-4, textfigs. 1g,h.

?	phillipsi	Wedekind 1908, p. 612, pl. XXXIX, fig. 26, XLIII, fig. 6.
	sulcata	Nalivkina 1953, p. 120, pl. V, fig. 11.
h?	tuberculata	Nalivkina 1953, p. 112, pl. IV, figs. 8,a, 9.

Remarks: No newly collected in situ material was available, nor were any species of Genuclymenia described by Münster. However, several useful comments can be made about the genus.

Genuclymenia angelini

Genuclymenia angelini has a subevolute, subglobose, discoidal shell form, with rounded flanks converging on a rounded venter. Growth-lines are prorsiradiate, concave. The only suture for this species was figured by Perna (1914, textfig. 4). Perna's specimen has growth-lines which are less prorsiradiate than the lectotype and therefore would be identified as Genu. aff. angelini. This has a flat ventral saddle with extremely shallow ventro-lateral lobes on it, a deep asymmetrical lateral lobe, and a V-shaped dorsal lobe.

Genuclymenia frechi

Genuclymenia frechi, the type species (e.g. Pl. 5.36, Figs. 12, 13, Textfig. 5.30B,C), has a more compressed shell form than Genu. angelini, but it is more involute (WW/WH = 0.88, U/D = 0.34; angelini WW/WH = 0.96, U/D = 0.36). Growth-lines are similarly shaped but strong ribbing is present here, especially on the body chamber. The suture, illustrated by Schindewolf (1957), when compared with Genu, angelini has an extra, incipient umbilical lobe (Textfig. 5.30C).

Genuclymenia guembeli

Two specimens of Genu. guembeli (KW 2061,3) collected from Wettmarsen and Enkeberg were available for study. These (Pl. 5.36, Figs. 6,7,9-11) have a distinctive discoidal shell form; the whorl section is compressed, quadrate (Textfig. 5.30H) with a tabulate venter, and clear midflank grooves on the body chamber. Growth-lines (Textfig. 5.30F) have the same course as on Genu. frechi, but with a much deeper, broader ventral sinus. The suture is typical for the genus (Textfig. 5.30G). The species sulcata Nalivkina and tuberculata Nalivkina (described originally as a species Cyrtoclymenia, and hence a homonym of tuberculata Kind 1944) are probably synonymous with Genu. quembeli, as all have a similar ornament.

Genuclymenia karpinskii

One well preserved specimen from Enkeberg (DK 80D 4511.1) is identified as Genu. aff. karpinskii (Perna). It has a shield-shaped whorl section and weakly biconvex, prorsiradiate growth-lines (Pl. 5.36, Figs. 14-16, Textfigs. 5.30I,J). The growth-lines are periodically bunched into groups of six or seven forming weak ribs, especially at the ventro-lateral shoulder, although these disappear near the presumed aperture, a half-whorl past the last septum. The external suture is like that of other species of Genuclymenia but there is an umbilical as well as a dorsal lobe. This feature is also shown by Genu. karpinskii (Perna), but on this the growth-lines have the prominent ventro-lateral salient found in other species of Genuclymenia, described above. Lange (1929) described a specimen from Enkeberg, like that described here, but assigned it to Protoxyclymenia cf. dunkeri (see above). Although this particular specimen has not been traced it is probably identical to the specimen illustrated in Pl. 5.36, Figs. 17,18, which was collected by Paeckelmann in 1925 from his trench at Enkeberg. Further discussion of these specimens can be found under Protoxy-clymenia dunkeri.

Genuclymenia borni

Schindewolf (1923a) described a new species, borni, from Kirch-Gattendorf. The specimen he figured (pl. XVII, fig. 4) cannot now be traced, but two specimens proposed as paralectotypes are illustrated in Pl. 5.36, Figs. 1,2. These (Mbg 3123, 3122) are small and poorly preserved, but show concavo-convex growth-lines with a prominent ventro-lateral salient, typical of other species. The validity of borni as a species is open to question since it resembles Genu. angelini, although with so few specimens available it is unwise to place them in synonymy.

Two specimens from Wäschholz, Oberfranken resemble no other described species. One (KW 2066; Pl. 5.36, Fig. 8, Textfig. 5.30D) has a shell form compressed, quadrate whorl section and growth-lines more typical of Platyclymenia, but it has an asymmetric lateral lobe, which distinguishes it. The other (KW 2067; Pl. 5.36, Fig. 5, Textfig. 5.30A), on which no suture has been observed, has biconvex growth-lines and a flatly arched venter. It is included here because of its close resemblance to Genu. aff. karpinskii.

The species phillipsi and tuberculata were both described as having Cyrtoclymenia sutures, although these were not illustrated. Therefore their inclusion within Genuclymenia is uncertain.

Dimensions:

	D	U	WW	WH
Genuclymenia frechi	28.9	8.1	10.0	12.9
KW 2095	23.7	7.8	8.0	9.8
Genuclymenia quenbeli				
KW 2061	19.7	10.5	10.5	10.4
KW 2063	42.7		ca13	15.4
Genuclymenia aff.	24.7	8.9	7.7	8.8
karpinskii	18.2	6.7	6.1	6.9

	D	U	WW	WH
Genuclymenia borni				
Mbg 3122	17.2	6.1		6.3
Mbg 3123	ca18.5	ca 3.5		
Genuclymenia sp.				
KW 2066, Pl.5.36, Fig. 8.	31	12.2		11.8
KW 2167, Pl.5.36 Fig. 5.		6.5		12.2

Horizon and distribution: Most of the species of Genuclymenia were established by Wedekind (1908), who stated that they came from the delphinus and annulata Zones. Later (1914) he restricted their range to IIIβ only. Schindewolf (1923a) suggested that Genu. borni, collected from his 1.8m thick Bed 10 at Kirch-Gattendorf, could be dated as IIIα. This section contained no Prolobites and therefore no unequivocal indications of IIIβ. The IIIα age was arrived at by the co-occurrence in Bed 10 of Pseudoclymenia.

Genus Cymaclymenia Hyatt 1884

p. 1832 Ammonites - von Buch, p. 179.
p. 1832 Planulites Parkinson - Münster, p. 13.
p. 1834 Clymenia Münster - Münster, p. 75.
p. 1853 Clymenia Münster - Sandberger, p. 191.
p. 1863 Clymenia Münster - Gümbel, p. 144.
p.* 1884 Cymaclymenia gen. nov. - Hyatt, p. 314 (rest: Biloclymenia).
p. 1887 Clymenia (Oxyclymenia) - Frech, p. 372, (rest: Kosmoclymenia).
p. 1897 Clymenia Münster - Foord and Crick, p. 27.
p. 1908 Varioclymenia gen. nov. - Wedekind, p. 606.
p. 1908 Oxyclymenia Hyatt - Wedekind, p. 621, (rest: Kosmoclymenia).
p. 1913 Oxyclymenia Guembel - Frech, p. 8 (rest: Ornatoclymenia, Kosmoclymenia).

1914 Cymaclymenia Hyatt - Wedekind, p. 26
1923b Miroclymenia gen. nov. - Schindewolf, p. 28.
1924 Postclymenia gen. nov. - Schmidt, p. 153.
1927 Cymaclymenia Hyatt - Wedekind - Schlosser, p. 6.
1928 Cymaclymenia Hyatt - Péneau, p. 180.
1929 Cymaclymenia - Delépine, p. 99.
p. 1931 Striatoclymenia gen. nov. - Matern, p. 95.
1935 Cymaclymenia Hyatt - Böhm, p. 64.
1949a Clymenia Hyatt - Schindewolf, p. 70,72.
1950 Cymaclymenia Hyatt - Termier and Termier, p. 75.
1952 Cymaclymenia Hyatt - Schindewolf, pl. 1.
1954 Cymaclymenia Hyatt - Pfeiffer, pl. VIII.
p. 1959 Cymaclymenia Hyatt - Lewowicki, p. 98, (rest: Ornatoclymenia).
1960 Cymaclymenia Hyatt - Selwood, p. 166.
1960 Cymaclymenia Hyatt - Kullmann, p. 537.
1962 Cymaclymenia Hyatt - House, p. 280.
1963 Cymaclymenia Hyatt - House, pl. 4.
1981a Cymaclymenia Hyatt - Korn, p. 181 (see here for other references to Cymaclymenia).

Type species: Planulites striatus Münster 1832, by original designation of Hyatt, 1884.

Diagnosis: Genus of the subfamily Cymaclymeniinae with a suture (Textfigs. 5.31F-I) consisting of a flat ventral saddle with a shallow ventro-lateral lobe, a distinctive, asymmetric quadrate acuminata lateral lobe, an asymmetrical umbilical lobe centred outside the seam, and a bell-shaped dorsal lobe.

Description: Shell coiling evolute to subevolute, umbilical widths ranging in mature specimens from 20-45% of the diameter. Inner whorls are evolute with a circular to compressed, quadrate whorl section, becoming generally compressed in later whorls (the ratio WW/WH varies from 0.5 to 1) with flattened slightly converging flanks and a rounded venter, which in some mature examples becomes tabulate, bounded by shallow ventro-lateral grooves. The impressed area comprises 10-50% of the whorl height, and up to 70% of the preceding whorl may be enveloped.

Growth-lines are generally concave, weakly biconvex with a sinus over the venter and a more or less prominent ventro-lateral salient. Some species, however, have sickle-shaped growth-lines. Ribbing, running parallel with the growth-lines, is common, especially near the umbilical shoulder where weak bullate nodes may develop. Strong concave asymmetric (steeper flank apicad) constrictions are present on the body chambers of most species.

The sutural ontogeny (newly described here) and especially the characteristic lateral lobe shape are best described by reference to Textfigs. 5.31F-M. The eighth septum (the earliest seen) has an asymmetric lateral lobe, which deepens and becomes quadrate, finally developing its pointed tongue-like shape. Schindewolf (1923b) demonstrated that the earliest septa of Cymaclymenia had a ventrad siphuncle (Textfig. 4.2a).

Available species names have recently been listed by Korn (1981a), who provided a comprehensive review of the genus. To his list can be added several other nominal species:

cordata	Wedekind 1914, p. 28, pl. II, figs. 12,13.
costata	Wedekind 1908, p. 606, pl. XLIV, figs. 3,a.
sagittalis	Phillips 1841, p. 125, pl. LIII, figs. 243a-c.
semistriata	Münster 1832, p. 14, pl. III, fig. 4.
serpentina	Schmidt 1924, p. 131, pl. 7, fig. 3.
umbilicata	Münster 1832, p. 14.

Species described here are restricted to those encountered in the Münster Collections, and camerata Schindewolf, evoluta Schmidt (= euryomphala Schindewolf), involvens Lange, the type specimens of which have recently come to light in the Museum für Naturkunde, Berlin, and sagittalis Phillips.

Comparisons: The genera most similar morphologically to Cymaclymenia are Kazakhoclymenia Bogoslovskiy 1979, and Laganoclymenia Bogoslovskiy 1979b. They can be distinguished by the presence of a ventral lobe, and Laganoclymenia also has a characteristic lateral lobe, with a very short ventrad flank (Textfig. 4.16).

Miroclymenia Schindewolf 1923b is a monospecific genus about which little is, or can ever, be known. It was based on a single juvenile (D = 15mm) specimen with a Cymaclymenia-type lateral lobe, and a ventral lobe, and therefore resembling Laganoclymenia. Schindewolf first considered (1924) Miroclymenia to be transitional to Wocklumeria, although he later (1937a) modified his ideas and regarded it as a "genus inquirendum". The type specimen was already lost by 1937 (Schindewolf 1937a). If the genus is later shown, by recollecting from the type area of Bohlen, Saalfeld, to be valid then it should be treated as the senior synonym of Laganoclymenia. Until then the type species, interpres, should be treated as a nomen dubium and not used. Consequently the family name based upon it (Miroclymeniidae Schindewolf 1924) and subsequently used by Ruzhencev 1957, Bogoslovskiy (1960, 1977, 1979, 1981) must fall or be treated as a junior synonym of Cymaclymeniidae.

Cyrtoclymenia and Genuclymenia both have representatives with a similar shell form and growth-lines to Cymaclymenia but they can be distinguished by their sutures. Pseudoclymenia, a tornoceratid, has an homeomorphic lateral lobe, but also has a deep narrow ventral lobe, and a more evolute shell form.

Remarks: A major problem in the description of this genus is the lack of a clear definition for most, if not all, of the species. Once this has been done an attempt must then be made to incorporate the many specimens figured as striata Münster into current classification. The comments below are confined to those species not covered individually.

The species _sagittalis_ (Phillips 1841, p. 125, pl. LIII, figs. 243a-c) collected from South Petherwin Cornwall, is now considered to be a _Cymaclymenia_. The holotype (GSM 7176) is subinvolute with a compressed whorl section and flattened flanks (Pl. 5.37, Figs. 5,6). Ornament is not preserved but the polished suture is clearly of the _Cymaclymenia_-type. No other known _Cymaclymenia_ has this characteristic shell form.

Horizon and distribution: This is probably the most widely distributed clymeniid genus. Examples are known from _Clymenia_ and _Wocklumeria_ Stufen of south west England, France, Belgium, West and East Germany, Poland, Austria, Italy, Algeria, Morocco, USSR (Urals, Kazakhstan), Australia (New South Wales), USA (Ohio, Iowa). _Cymaclymenia_ _evoluta_ occurs in the Hangenberg Schiefer of Westphalia and is the youngest known clymeniid.

Several authors (Wedekind 1908, 1914, Schindewolf 1923a, Schmidt 1924) have asserted that _Cymaclymenia_ occurs in the _Platyclymenia_ Stufe. There is much circumstantial evidence to contradict this, especially Brügge's (1973) study of the _Platyclymenia_/_Clymenia_ Stufen boundary. Wedekind (1914) reported that the species _costata_, which he had earlier (1908) described as a _Varioclymenia_, had a _Cymaclymenia_ suture. This species had been collected from Bed 11, the "beds with _Prolobites_ _delphinus_ and _Clymenia_ _involuta_", i.e. _delphinus_ Zone. Lange's (1929) account of the Enkeberg faunas did not, however, confirm this occurrence.

Schindewolf (1923a) reported an unnamed species which he had encountered in the _Postprolobites_ Stufe of Ebersdorf, and in 1952 he recorded (p. 285) a "mixed" fauna comprising _Cymaclymenia_ cf. _striata_ and _Platyclymenia_ (_Plat_.) cf. _annulata_, which could be considered as being from the annulata Zone.

Schmidt (1924) stated that _Cyma_. _striata_ appeared in the annulata Zone, but did not provide any substantiating evidence. Matern (1931) recorded Prolobites delphinus and Cymaclymenia compressa from Bed la of Trench I at Sessacker, which he considered to represent IIIβ levels.

This review of occurrences of Cymaclymenia from the Platyclymenia Stufe demonstrates how circumspect these records are. Korn (1981a) accepted the records, but was unable to substantiate them. The least that can be said is that it has still to be shown unequivocably that Cymaclymenia occurs below the Clymenia Stufe.

Three groups of species are distinguished by their ornament: striata group, with lirate growth-lines varying in course from concave to concavo-convex to biconvex; dorsocostata group, with blunt ribs; and costellata group, comrpising species where ribs are formed by the bunching together of growth-lines. Cymaclymenia aff. striata and Cyma. serpentina are intermediate in form between the striata and costellata groups.

striata Group

Cymaclymenia striata (Münster 1832)

Pl. 5.37, Figs. 7-11, Textfigs. 5.31A-C, 5.32

* 1832 Planulites striatus - Munster, p. 14, pl. III, figs. 3a-c.
1834 Clymenia striata Münster - Münster, p. 76, pl. III, figs. 3a-c (translation of Münster 1832)
1843 Clymenia striatus Münster - Münster, p. 9, pl. IIIa, figs. 3a-c (copy of Münster 1832).
non 1981a Cymaclymenia striata Münster - Korn, p. 187, and all the references contained therein.

Type material: A neotype, SM H10414, in the Münster Collection, Sedgwick Museum, from Schübelhammer, Oberfranken, is proposed here.
Remarks: No trace can be found of the type series, which consisted of two specimens (Münster 1833, p. 110), and even Gümbel figured only a "typische" specimen (1863, p. 164). This same specimen (BSP AS VII 545, Pl. 5.37, Figs. 12,13) was held by Korn (1981a) to be Münster's holotype. This designation is invalid on two counts: firstly there can be no holotype since the type series consisted of more than one specimen, and secondly the specimen could not even be proposed as the lectotype since it differs greatly from Münster's (1832) figure (see below). A neotype is proposed to rectify the situation, using a specimen from the type locality, which greatly resembles the original figure.
Diagnosis: Cymaclymenia with concave prorsiradiate lirate growth-lines numbering 16 per centimetre at a diameter of 35mm, an umbilical width amounting to 35-40% of the diameter, a compressed whorl section, the ratio WW/WH being between 0.55 and 0.65, with slightly converging flanks and no ribbing.
Material: Three specimens from Schübelhammer were available for study: two collected by Münster, SM H10414 and BM 81824 (formerly 81824a), and HU P82.20.

Description: The well preserved specimen from the Sedgwick Museum (Pl. 5.37, Figs. 7-10, Textfigs. 5.31A-C) was sectioned, although all but the last whorl appears to have been dissolved by stylotitisation. The coiling is evolute, with the umbilicus amounting to 36-38% of the diameter at diameters between 20 and 40mm. The whorls are compressed, with the greatest width at the umbilical shoulder and flanks converging to a narrow rounded venter at a diameter of 35mm. Earlier than this the venter is broader, flatter, and the flanks less converging.

Growth-lines, expressed as distinct lirae, are widely spaced, numbering ca 16 per centimetre at a diameter of 35mm. They are concave, prorsiradiate with a broad ventro-lateral salient, curving over into U-shaped ventral sinus (Textfig. 5.31C). Ribs are not present externally, but the internal mould shows weak plicate ribs running parallel with the growth-lines. The body chamber is preserved through 150^o.

The suture is illustrated in Textfig. 5.31B, and the lateral lobe is quadrate and pointed in the ventrad corner.

The specimen in the British Museum (NH) (Pl. 5.37, Fig. 11) shows features exactly similar to the Cambridge specimen, but near to the former aperture the growth-lirae are approximated, finer, and the ventro-lateral salient is more prominent.

Dimensions:

	D	U	WW	WH	A
SM H10414	40.2	13.9	ca10	14.9	10.1
	35.8	13.5	7.9	13.7	
	25.6	9.8	6.3	9.1	6.8
	18.8	7.1	4.4	6.7	
BM 81824	33.6	12.3		13.2	
Münster 1832,	50	16	9	18	
pl. III, fig. 3.	38	11		17	

Remarks: There seems to be no specific description in the literature which can be certainly referred to Cymaclymenia striata. Indeed Schindewolf has already (1923a, p. 437) remarked that the specific name has been used for anything with a Cymaclymenia suture (cf. Kosmoclymenia undulata and Gonioclymenia speciosa). Such confusion results, as ever, from the failure of previous authors to interpret the species from its original description (Münster 1832, p. 14), which was (in translation):

> The shell has wavy single well defined fine striations, which run forwards in a circular curve over the margin of the venter, and then curve backwards as deeply. Examples (sic: i.e. plural) found as yet are 1½ inches in diameter and are the same in shape and number of whorls as Pl. costellatus. Also the lobe and saddle are little different. It seems that this is only a juvenile of

_Pl_. _costellatus_, which would later develop finer striations and ribs.

The illustration provided by Münster is slightly at odds with this description, especially the whorl shape, shown as compressed with parallel flanks and a ratio WW/WH of 0.53, compared with 0.68 for the lectotype of the tabulate ventered _costellata_ (see below), with which similarity was alleged.

Discussion: There is little help from the literature in defining this, the type species of _Cymaclymenia_. If only modern authors (i.e. 20th century) are consulted agreement is still hard to find.

Wedekind (1908) assigned a number of specimens to this species; they possessed numerous weak ribs, but the growth-lines were not preserved. Later (1914), Wedekind included these examples within _Cyma_. _costata_, and recognised striata as being the species with "flattened parallel flanks and a rounded venter". He considered Münster's figure to be "uncertain" (although he claimed to have a specimen from the Fichtelgebirge which closely resembled it) and Gümbel's description to be inadequate. Wedekind identified none of his Sauerland material as _Cyma_. _striata_.

Schindewolf(1923a) appears to have included a wide range of forms within _striata_ (see his synonymy). His definition ran "narrowly umbilicate, flanks weakly curved and almost parallel, compressed whorl section with whorl height: whorl width ratio greater than two". No photographic illustrations were provided but there was a sketch of the whorl outline (fig. 17a), although the specimen on which this was based cannot now be traced. The dimensions of two specimens were provided in Schindewolf's account and one was described as well preserved and from the Glass Collection at Munich. A label identifies this, unnumbered specimen, at

Munich but although it has similar dimensions (Pl. 5.39, Fig. 2) it is certainly not well preserved, and has probably been labelled in error.

Schmidt (1924) considered that he had seen over 300 examples of Cyma. striata from the Sauerland, where it ranged "from the annulata to Wocklumeria Zones". He stated that he interpreted the species broadly, in terms of whorl outline and ornament. Neither of the two specimens he illustrated (1924, pl. 7, figs. 1,2) resemble the species; that in fig. 1 has blunt ribs (Pl. 5.40, Fig. 11) and is identified as Cyma. aff. costellata, and that in fig. 2 has a prominent ventro-lateral growth-line salient (Pl. 5.40, Fig. 7) and is identified as Cyma. aff. serpentina.

Lange (1929) did not recognise Cyma. striata, which is remarkable since he and Schmidt had available to them specimens from the same sections and museum collections. Lange seems largely to have ignored the Prussian Survey Collections in his accounts, and referred only to his own material, which he named as Cyma. compressa Münster, defined by Gümbel's (1863, pl. XVIII, fig. 6) illustration of the species. However, it is more likely that identification was based on a comparison with the figures of Cyma. cordata Wedekind (1914, pl. 2, figs. 12,13) with which Schindewolf (1923a) had placed Cyma. compressa in synonymy.

Matern (1931) followed Lange's usage of compressa, and introduced a new generic name, Striatoclymenia, with striata Münster as its type, incorrectly recognising Gümbel's usage of the group name Cymaclymeniae as a valid genus, with Cl. bilobata as its type species. Matern then proceeded to argue that the species bilobata should be included in Selloclymenia Gümbel which he then treated (again incorrectly) as the senior synonym of Cymaclymenia. Later an ICZN opinion (Opinion 182) invalidated Gümbel's group names, giving authorship to Hyatt (1884).

When Schindewolf described the more unusual elements of the Wocklumeria Stufe clymeniid fauna (1937a) he avoided considerations of Cymaclymenia and unhelpfully included all forms except barbarae and euryomphala within Cyma. striata. Korn (1981a) has only recently revised the genus Cymaclymenia, and it is necessary to explain why his interpretation of the type species is discounted. Korn's diagnosis runs:

> shell more or less thinly discoidal, flanks flattened converging slightly towards the venter. Umbilical width less than one quarter of the diameter in mature specimens. Growth-lines biconvex, bunched near the umbilicus. Many strong constrictions on the internal mould.

His selection of BSP AS VII 545 as the holotype has already been argued against above, and none of the specimens he figured resembles Münster's original figure. The species as illustrated by Münster, and defined here has lirate growth-lines which are more widely spaced and lacking bunching near the umbilicus.

Korn figured a number of specimens to illustrate Cyma. striata (figs. 8c,d, 11a-h). Of these 11h is a juvenile, 11f,g have no growth-lines preserved, 11e has bunched growth-lines, 11c,d is the lectotype of Cyma. semistriata, treated here as a separate species, and 8c,d has a tabulate venter and very fine growth-lines, which become bunched at a diameter of ca 30mm. This last specimen and 11a (Korn's holotype of striata) and 11b are all treated here as Cyma. aff. striata, since they have fine growth-lines (ca 65 per centimetre on fig. 8c at a diameter of 30mm, compared with 16 per centimetre on the neotype, at a similar diameter). Their whorl cross-sectional shape is unknown.

Comparisons: Cyma. aff. striata and Cyma. camerata are similar in shell form to Cyma. striata, but can be distinguished by their growth-line frequency and therefore may warrant only subspecific taxonomic status. Cyma. camerata also has a thicker whorl section and a narrower umbilicus and Cyma. aff. striata has a narrower umbilicus and slightly thicker whorl section. Most other species of Cymaclymenia are ribbed. Clearly the lack of stratigraphic control or large samples means that the possibility of this variation being encompassed by one population cannot be evaluated.

Horizon and distribution: This species is known only from Oberfranken, and its stratigraphic position is uncertain.

Cymaclymenia aff. striata (Münster 1832)

Pl. 5.37, Figs. 12,13,17-20

v* 1863 Clymenia striata Münster - Gümbel, p. 144, pl. XV.
pv 1923a Cymaclymenia striata Münster - Schindewolf, p. 437.
pv 1981a Cymaclymenia striata Münster - Korn, p. 187, figs. 8c,d, 11a,b, only.

Material: Three specimens are included here, all collected by Münster from Schübelhammer; BSP AS VII 545, UEN 92, and an unnumbered specimen in the Museum für Naturkunde, Berlin.

Description: These three specimens are discussed principally to describe the poorly preserved specimen (BSP AS VII 545), which has formerly been accepted as the type of striata (see Gümbel 1863, pl. XVII, figs. 1a-c; Korn 1981a, p. 189).

This specimen (Pl. 5.37, Figs. 12,13) is large, weathered and filed in parts to reveal the suture. The umbilicus amounts to 25% of the diameter at a diameter of 50mm, where the whorl section is compressed and the ratio WW/WH is 0.70. A few biconvex growth-lines, in groups of 6 or 7 forming weak ribs, are preserved near the aperture where they are biconvex and radial, with a broad mid-flank sinus.

The other two specimens are little better preserved. That in Berlin is embedded in matrix (Pl. 5.37, Fig. 20) the umbilical width amounts to 30% of the diameter at a diameter of 50mm, although this is infilled with matrix. The growth-lines numbering 30 per centimetre at a diameter of 50mm, are biconvex, prorsiradiate, bunched into groups of 5-6 near the umbilicus with the ventro-lateral salient being prominent, whereas one whorl earlier the growth-lines are biconvex, prorsiradiate, with a broad mid-flank sinus. No further details are visible, except for the weak ribs on the internal mould of the body chamber, near the ventro-lateral shoulder.

The final example (Pl. 5.37, Figs. 17-19) has most of its shell weathered away. The umbilical width amounts to 28% of the diameter at a diameter of 55mm. The whorl section is compressed, with a maximum width at the umbilical shoulder, flanks converging to a narrow rounded venter, and a ratio WW/WH of 0.65. The growth-lines, where visible, are biconvex, fine, clearly spaced and bunched into groups of 4-5 near the umbilicus, with a deep V-shaped sinus over the venter. Weak ribs are present on the internal mould over and near to the venter.

Dimensions:

	D	U	WW	WH	A
BSP AS VII 545	49.6	12.3	14.7	21.1	
MfN	50	15		21.5	
UEN 92	55.8	15.2	16	24.8	17.3

Discussion: It is not claimed that these three specimens are identical, merely that they bear similarities in shell and growth line shape, which make it difficult to distinguish between them.

Attention has already been drawn to the incorrect designation of a holotype for Cyma. striata, by Korn (1981a). BSP AS VII 545 was the specimen he selected as the holotype, identifying it as the one figured by Gümbel (1863, pl. XVII, figs. 3a-c) as "Clymenia striata typische Form". Clearly this specimen does not resemble Münster's original figure (1832, pl. III, figs. 3a-c). The type series contained more than one example, so BSP AS VII 545 is rejected as the holotype on two counts (see Cyma. striata).

How much imagination Gümbel used in illustrating this specimen can be seen by comparing the photographs with his figure. Virtually a complete whorl's length of growth-lines, all with a deep mid-flank sinus and shallow ventro-lateral grooves have been added. Indeed were it not for the resemblance in gross morphology, and the parallelism in areas of shell removed to reveal the suture, and the inscription in black ink on the specimen "T XVII", it would be difficult to believe that they were based on the same original. It is not surprising, therefore, that authors have experienced difficulty in interpreting Cyma. striata.

Inclusion here of the specimens figured by Korn (1981a) has been discussed above under Cyma. striata.

Comparisons: Cymaclymenia striata has a similar shell and growth-line shape, but the growth-line frequency is about one half of that observed in this species.

Horizon and distribution: The specimens described here were collected in Oberfranken and the Sauerland. An horizon is known only for Korn's specimens, namely the Wocklumeria Stufe.

Cymaclymenia camerata Schindewolf 1923a

Pl. 5.37, Figs. 2-4, 14-16, Textfigs. 5.31D,E, 5.32

*vp	1923a	Cymaclymenia camerata sp. nov. - Schindewolf, p. 441, pl. XVII, fig. 6; fig. 17b, non pl. XVII, fig. 5.
non	1923b	Cymaclymenia camerata Schindewolf - Schindewolf, p. 25, figs. 1,2.
non	1926	Cymaclymenia camerata Schindewolf - Schindewolf, p. 96, fig. 2.
?	1929	Cymaclymenia camerata Schindewolf - Delépine, p. 99 pl. VI, figs. 1-3.
non	1960	Cymaclymenia camerata Schindewolf - Petter, p. 49, pl. VIII, figs. 15,a, figs. $5B_{,1}$.
non	1960	Cymaclymenia camerata Schindewolf - Selwood, pl. 27, figs. 6,7.
	1981a	Cymaclymenia camerata Schindewolf - Korn, p. 200.

Type material: The specimen figured by Schindewolf (1923a, pl. XVII, fig. 6), currently in the Museum für Naturkunde, Berlin, is proposed as the lectotype.

Diagnosis: Cymaclymenia with an umbilical width amounting to 30-35% of the diameter, and a whorl width: whorl height ratio of 0.6-0.8. The growth-lines are coarse, concave with a prominent ventro-lateral salient, and number about 16 per centimetre at a diameter of 25mm.

Description: Two specimens only were available for description: the lectotype (MfN), from Bed 18, Kirch-Gattendorf (Schindewolf 1923a) and illustrated here in Pl. 5.37, Figs. 2-4, and SM H10415, from the Münster Collection, Schübelhammer, illustrated in Pl. 5.37, Figs. 14-16 and Textfigs. 5.31D,E.

Little can be added to the diagnosis. The whorl cross-section (Textfig. 5.31D) becomes more compressed at greater diameters and evolution decreases. The growth-lines, preserved only in the ventral regions of the lectotype are figured from SM H10415 in Textfig. 5.31E. They are concave, prorsiradiate with a prominent ventro-lateral salient, and a deep U-shaped ventral sinus.

The suture, unknown from SM H10415, and revealed by polishing on the lectotype, is subdued and of little help in diagnosing the species.

Dimensions:

	D	U	WW	WH
Lectotype, MfN pl.5.37,figs.2,3	26	9.4	ca 9.5	11.4
Schindewolf 1923a pl.XVII,fig.5	22.4	5.8	4.2	9.1
	16.5	6.8	3.8	7.0
SM H10415	40.2	13.9	9	15.8
	29.4	9.9		11.7

Remarks: Schindewolf (1923a, p. 426) diagnosed the species as "narrowly umbilicate, involution ½ -⅔ , without secondary sculpture flanks curved and relatively depressed, Vβ - VI" and (p. 441, fig. 17b) gave measurements for the specimen he illustrated in pl. XVII, fig. 6. This description fits only one of the examples illustrated by Schindewolf hence its selection as the lectotype. The identity of the other, more compressed specimen, which also lacks growth-lines, is uncertain.

Discussion: Schindewolf used this specific name widely for examples of Cymaclymenia, with a wider umbilicus than Cyma. striata, from the uppermost Devonian of Oberfranken, Drewer and Elberfeld (1923b figs. 1,2; 1926, fig. 2). Later Delépine (1929) identified Cymaclymenia camerata from the Étroeungt of northern France, All of these specimens were included by Schindewolf (1937a) in the species Cyma. euryomphala, and I will follow his opinion because no precise details of the material he described in 1923b and 1926 were ever published. Schindewolf (1937a, p. 14) discussed the difference between striata, camerata and euryomphala nom. nov.

(= evoluta of this account), "(in striata) ... up to a diameter of 35mm the umbilical width and apertural height are equal, and then the umbilical width increases to become equal to the whorl height. The umbilical width of camerata is already equal to the whorl height at diameters less than this". The other species, euryomphala, was then described simply as "widely umbilicate".

Such narrow distinctions are not useful unless they can be validated by statistical studies of populations. Whilst the observations may be true for the specimens that Schindewolf saw, actual documentation is lacking. Growth curves for various parameters are plotted in Textfig. 5.32. None seems of diagnostic value in identifying species, except for the ratio U/D of Cyma. involvens. Consequently, I have chosen to distinguish between these three species on the basis of growth-line frequency. This criterion suffers from the same drawbacks as the characters chosen by Schindewolf, and would have to be validated by study of populations. It does, however, seem an easier and less subjective means of distinguishing between the few specimens at my disposal.

The specimen figured by Petter (1960) cannot be included here because it has radial, biconvex growth-lines, and the specimen figured by Selwood also has different growth-lines from Cyma. camerata, and is discussed below under Cyma. aff. serpentina.

Korn (1981a) described a single specimen which had the same dimensions as the lectotype.

Horizon and distribution: The lectotype was collected by Schindewolf from Bed 18 at Kirch-Gattendorf, which he considered to be in Vβ.

Cymaclymenia evoluta (Schmidt 1924)

Pl. 5.38, Figs. 10-13, Pl. 5.39, Fig. 3. Textfigs. 5.31M-O; 5.32

nom. nud.	1897	Cl. evoluta - Frech, p. 179, Footnote 2.
?	1921	cf. Pseudoclymenia - Schmidt, p. 294.
non	1923a	Cymaclymenia camerata sp. nov. - Schindewolf, p. 441, pl. XVII, figs. 5,6.
	1923b	Cymaclymenia camerata - Schindewolf, p. 25, figs. 1,2.
v*	1924	Postclymenia evoluta Frech - Schmidt, p. 154, pl. 8, figs. 19-21.
	1926	Cymaclymenia camerata Schindewolf - Schindewolf, p. 95, figs. 2a,b.
?	1929	Cymaclymenia camerata Schindewolf - Delépine, p. 99, pl. 6, figs. 1-3.
	1937a	Cymaclymenia euryomphala nom. nov. - Schindewolf, p. 14.
v	1939	Cymaclymenia euryomphala Schindewolf - Paul, p. 656, 676, pl. 40, fig. 3, pl. 41, fig. 3.
	1981a	Cymaclymenia euryomphala Schindewolf - Korn, p. 201, figs. 19b, 21.

Type material: The specimen illustrated by Schmidt (1924) in pl. 8, fig. 19 is proposed as the lectotype, and that in pl. 8, fig. 21 as the paralectotype. Both are housed in the Museum für Naturkunde, Berlin.

Remarks: Schmidt (1924) listed a type series of 40 specimens, 14 from the Elberfeld area, and the remainder from Drewer. The proposed type locality is the Ost Provinzial Steinbruch, Drewer, and the horizon of the lectotype was given by Schmidt as "Étroeungt".

Diagnosis: Cymaclymenia with open umbilicus in early whorls, becoming narrower after a diameter of ca 35mm and flattened almost parallel flanks, tabulate venter and quadrate almost square lateral lobe. Fine, closely spaced prorsiradiate convex growth-lines.

Description: Only three well preserved specimens are available for description, the lectotype, the paralectotype and RE 551 734.5 A373, labelled as from "E_β, Bed 21, obere Abschnitt, Ratingen, Cromford", and figured by Paul, 1939, pl. 41, fig. 3. These three specimens are figured in Pl. 5.38, Figs. 10-13, Pl. 5.39, Fig. 3, and Textfigs. 5.31M-O. All are preserved squashed, in shales, and the finer details of shell ornament etc. are no longer present.

The lectotype, selected because it shows a Cymaclymenia suture, is visible on the bedding surface of calareous mudstone. The umbilical width comprises 30% of the diameter and the whorl height about 35%, at a diameter of 32mm. Growth-lines are not preserved and the body chamber has a longitudinal crack on the mid-flank caused by compaction of the shell. The polished sutures were accurately represented by Schmidt (1924, pl. 8, fig. 19).

The paralectotype is slightly better preserved, with traces of concave, prorsiradiate growth-lines remaining. There is a ventro-lateral salient over the ventrad part of the flank. The umbilical width comprises 36% of the diameter at a diameter of 37mm. Coiling and whorl shape are visible on this relatively uncrushed specimen (Pl. 5.38, Fig. 13) whorl height increases rapidly and there is a shallow impressed area, the flanks are flattened and converge gradually towards a flattened venter.

The specimen from Cromford (RE 551 734.5 A373) is preserved as a distorted internal mould, and although no traces of ornament are preserved the sutures are stillvisible. What is considered to be the least distorted one is figured in Textfig. 5.31M.

Another specimen (RE 551 734.5 A371), labelled as from Scharpenhaus, north of Heiligenhaus, is preserved as an external mould on a bedding surface of a brown/green weathering mudstone, was considered by Paul (1939) to come from the same level (E_β) as A373. This large specimen, although totally flattened, shows the trace of a suture at a diameter of 80mm. Beyond this biconvex, prorsiradiate growth-lines, similar in shape to those of the paralectotype, are preserved on the body chamber. This together with the suture, are illustrated in Textfigs. 5.31N,O. The large size of the specimen and the subtriangular shape of the lateral lobe cause this specimen to be identified as Cyma. cf. evoluta.

Dimensions:

	D	U	WH
Lectotype, MfN Pl.5.38,Fig.10	32	11	11
Paralectotype, MfN Pl.5.38,Figs.12,13	37.9	11	11
RE 551 734.5 A373	41.8 28.8	12.9 8.2	16.8 16.8
RE 551 734.5 A371	80	22	34

Discussion: Firstly the contents of the synonymy list will be explained, and then the nature of the species, especially as it was envisaged by previous authors, will be discussed.

The first use of the specific name was by Frech (1902) who simply stated "Eine eigenthumliche Clymenia (Cl. evoluta) bildet in Belgien die einzige Ausnahme". Therefore the undescribed Clymenia evoluta is a nomen nudum. No clymeniids were then known from Belgium, except for the note by Hébert (1848) of Cl. undulata.

Schmidt recognised a ventral lobe on a specimen from Drewer (1921) which he referred to cf. Pseudoclymenia (whose lateral lobe and shell form are homeomorphic with Cymaclymenia). Later (1924) he erected a monotypic genus Postclymenia, with the species evoluta Frech as its type species, for what may have been the same specimens, since both Postcl. evoluta and cf. Pseudoclymenia were recorded from the Étroeungt of Drewer. However, Schmidt did not himself place them in synonymy, and without seeing the material he mentioned in 1921 one can never be certain.

Schmidt's use of the species evoluta Frech is totally lacking in foundation, since that species was never described. Presumably Schmidt considered any supposed occurrence of clymeniids in Belgium to be from the Étroeungt and thus comparable with his new genus, which, as the name may suggest, was similar to a clymeniid. However, since Cl. evoluta Frech is a nomen nudum, and thus invalid, and evoluta Frech sensu Schmidt was introduced in a different genus, Postclymenia evoluta Schmidt then becomes a valid species name, now recognised to be a Cymaclymenia.

Schindewolf (1937a), in an argument totally ignoring the account of Schmidt 1924, proposed a new name, euryomphala, for Cl. evoluta Frech, which he regarded as a nomen nudum. He obviously considered evoluta sensu Schmidt to be the same as his understanding of evoluta Frech, because he chose a specimen illustrated by Schmidt (pl. 8, fig. 19) as the holotype of euryomphala. A nomen novum can only be introduced as a new name to replace a preoccupied name. Clearly this is not the relationship between Cl. evoluta Frech and Postclymenia evoluta Schmidt, and will never be, since Cl. evoluta Frech is invalid as nomen nudum. The sense of Cymaclymenia euryomphala is preserved by selecting its holotype as the lectotype for evoluta Schmidt. Unfortunately neither name is apt since the coiling and umbilical width alluded to by it are not distinctive features (Textfig. 5.32).

Not so clear is the relationship between Cyma. camerata Schindewolf 1923a and this species. Schindewolf (1923a) described this species using material from Kirch-Gattendorf (see above). Later (1923b) he described a protoconch, and then figured a suture (1926), based on material collected from Drewer, from the same horizon as that from which Schmidt had collected Postcl. evoluta. Schindewolf assigned his and Schmidt's specimens to Cyma. camerata.

Cymaclymenia camerata Schindewolf 1923a is distinguished from evoluta by its shell form and growth-lines, but Cyma. camerata Schindewolf 1923b, 1926 is placed in synonymy with Cyma. evoluta, recognising that Schindewolf did not have available well preserved examples with growth-lines which he could compare with his Bavarian material.

In 1929 Delépine described a single poorly preserved specimen as _Cyma_. _camerata_. Although Schindewolf (1937a) placed this in _Cyma_. _euryomphala_ its shell form is closer to _Cyma_. _camerata_. No growth-lines were visible.

Horizon and distribution: This species is considered to be confined to the Hangenberg Schiefer of the Rheinische Schiefergebirge. The _euryomphala_ Zone of Schindewolf 1937a, defined as the Hangenberg Schiefer of the Oberrödinghausen railway cutting should be renamed the _evoluta_ Zone.

Cymaclymenia _involvens_ Lange 1929

Pl. 5.38, Figs. 7,8,10, Textfigs. 5.31L, 5.32

v*	1929	_Cymaclymenia_ _involvens_ sp. nov. - Lange, p. 91, pl. 2, figs. 23, textfigs. 23,4.
?non	1960	_Cymaclymenia_ _involvens_ (Lange) - Petter, p. 47.
	1979	_Cymaclymenia_ _involvens_ (Lange) - Korn, p. 53.
	1981a	_Cymaclymenia_ _involvens_ (Lange) - Korn, p. 194, figs. 14-16.

Type material: The holotype figured by Lange (1929) is an unnumbered specimen in the Museum für Naturkunde, Berlin. A paratype (MfN) is proposed here, being the specimen upon which Lange based his illustration of the suture of the species.

Description: Only the type material has been seen. The holotype (Pl. 5.38, Figs. 7,8) has a compressed whorl section (WW/WH = 0.80) and a narrow umbilicus, amounting to 33% of the diameter, at a diameter of 21mm. The measurements given here for the holotype differ considerably from those given by Lange, (but there can be no question of the identity of the specimen since it was illustrated by Lange). The flanks are flattened and converge on a broad, rounded venter. The umbilical shoulder is angular, and the umbilical wall steep and clearly developed.

The lirate growth-lines are well preserved on the shell of the holotype, although they are not visible on the internal mould. They have a shape which is not quite concave. Over the dorsad half of the flanks they run radially or slightly convexly, and then swing strongly forwards to form a ventro-lateral salient. The growth-lines are grouped into threes over the radial portion of their course, and form weak ribs near the umbilical shoulder, especially at the maximum preserved diameter, where they are closer together. Their frequency is 36 per centimetre at a diameter of 20mm. There is no major ribbing, nor is any ornament evident on the internal mould. The suture is not visible on this specimen.

The proposed paratype is weathered and lacks shell. The flanks are compressed and the venter narrow. The umbilical width amounts to only 18% of the diameter at a diameter of 40mm. The suture, with a relatively deep ventro-lateral lobe, is illustrated in Textfig. 5.31L.

Dimensions:

	D	U	WW	WH
Holotype, MfN	21	7	7	8.7
Holotype, _fide_ Lange 1929, p.91	25	5	9.8	12.2
Paratype, Pl.5.38 Fig. 10	41.2	7.1	15.5	20

Remarks: Lange considered these two specimens to be conspecific although it is difficult to see how he arrived at this decision since they have no common features. Lange himself stated that the holotype was more widely umbilicate than the other seven specimens he had available.

Discussion: Subsequent authors have experienced difficulties in interpreting this species, not surprisingly. Schindewolf pointedly avoided describing Cymaclymenia when he studied the Wocklumeria Stufe faunas of the Hönnetal (1937a) and included most examples with Cyma. striata.

None of the specimens assigned by Petter (1960) to this species appears to resemble either of the type specimens. She gave the dimensions of 10 specimens ranging in size from 22-44mm. These had a ratio U/D ranging from 0.37 - 0.50, and WW/WH ranging from 0.84 - 0.80. Comparable ratios for the holotype and paratype were 0.33 and 0.80, and 0.18 and 0.78 respectively. Therefore, Petter's specimens are too consistently compressed and widely umbilicate to be included within Cyma. involvens.

Petter described the growth-lines as being comparable to those of the holotype. Such growth-lines are visible on the specimen she illustrated in pl. 8, fig. 6,a, but those on the specimen in pl. 7, fig. 10 are radial and biconvex. No other specimens show the growth-lines. An example from Schübelhammer (SM H10381), illustrated in Textfigs. 5.31J,K is comparable with this latter specimen. Also Petter was wrong to state that Schindewolf (1937a) had regarded his earlier species (1923a Cyma. ovata, nom. nud.), described simply as having a "narrow umbilicus", as synonymous with Cyma. involvens. He merely grouped Cyma. striata, involvens and ovata loosely together.

Lately Korn (1981a) has redescribed the species using 15 specimens from various localities in the Sauerland. He found Cyma. striata and involvens difficult to separate, and did so graphically (fig. 10) on the basis of the ratio WW/WH. Unfortunately the holotype of Cyma. involvens falls into the field for Cyma. striata (described herein as Cyma. aff. striata). Korn's graph does show, however, that the plots for the two "species" form a "continuum". Also included in this species by Korn were examples lacking growth-lines (e.g. fig. 16c), a practice difficult to justify.

Horizon and distribution: The holotype was probably from the lower Wocklumeria Stufe, at Burg, Wocklum, and Korn (1981a) has reported the species from the Clymenia and Wocklumeria Stufen throughout the Sauerland.

Cymaclymenia aff. barbarae (Loewinson-Lessing 1892)

Pl. 5.38, Figs. 1,2, Pl. 5.40, Figs. 1,2, Textfigs. 5.33I,J

aff.* 1892 Clymenia barbarae sp. nov. - Loewinson-Lessing, p. 20, pl. 2, figs. 1a-c.

v 1929 Cymaclymenia barbarae Loewinson-Lessing - Lange, p. 90, fig. 20.

? 1952 Clymenia cf. barbarae Loewinson-Lessing - Schindewolf, pl. 1, fig. 1.

Type material: The type material was stated by Loewinson-Lessing to be in Dorpat (= Tartu, Estonia). The specimen figured by him is treated as the lectotype.
Material: An unnumbered specimen in the Museum für Naturkunde, Berlin, from Melschede, figured by Lange (see above).
Diagnosis: Accepting Loewinson-Lessing's description, the diagnostic features of Cyma. barbarae are: a compressed shell form with flat venter and almost flattened flanks with a faint mid-flank depression. The growth-lines are weakly biconvex, with a broad shallow sinus running across the whole flank, and a shallow sinus over the venter. By contrast this species has growth-lines which are truly biconvex and the mid-flank sinus occupies only one half of the flank.

Description: The fragmentary portion of body chamber figured by Lange conforms closely with the description and figure of Loewinson-Lessing. The umbilicus, unknown to Loewinson-Lessing, although incomplete appears to be very narrow. No suture can be seen.

Remarks: Two further specimens are identified as Cymaclymenia aff. barbarae. The first (KW 2084) illustrated in Pl. 5.38, Figs. 1,2, and collected from a level in the subarmata Zone at Reigern (Bed 33), has a similar shaped but broader whorl section, a narrow umbilicus (U/D is 0.23) and weakly biconvex growth-lines, which are bunched to form weak ribs, especially near the umbilical shoulder.

A second, smaller unnumbered specimen (Pl. 5.40, Figs. 12,13) in the Museum für Naturkunde, Berlin, collected by Münster from Schübelhammer, also has a similar shell form. On this the lirate growth-lines are concave, prorsiradiate bunched to form weak ribs but with a deeper mid-flank sinus. There is a broad U-shaped sinus on the venter. The ribs are expressed as weak tubercles around the angular ventro-lateral shoulder.

Dimensions:

	D	U	WW	WH
Loewinson-Lessing 1892, p. 20.	45		11	16
MfN, Pl.5.40, Figs. 1,2.			10.3	19.5
MfN, Pl.5.40, Figs. 12,13.	24.8	6.5	6.9	8.2
KW 2084	47.2	10.8		21.9

Discussion: Grouped here are a number of specimens with one common feature, a broad tabulate venter. The specimen most similar to Cyma. barbarae is that from Schübelhammer with a close shell form and growth-line shape. The tabulate venter appears, however, to be developed only in the last half whorl of this specimen. Where the venter is rounded it would be difficult to distinguish this specimen from Cyma. camerata.

The distorted specimen from the Wocklumeria Stufe of Bohlen, Saalfeld which Schindewolf (1952) figured is difficult to evaluate. No growth-lines are visible in the illustration, nor was the specimen described. It appears to have a flattened venter, and thus may belong here.

Cyma. aff. barbarae (i.e. barbarae sensu Lange) has biconvex growth-lines, rather than convex, and a narrower umbilicus and KW 2084 probably represents a well preserved example of this specimen.

Horizon and distribution: Lange stated that his specimen came from Vβ, and KW 2084 comes from the subarmata Zone. The horizons of the other specimens discussed are unknown.

Cymaclymenia sp. a

Pl. 5.39, Figs. 4-6, Textfigs. 5.33L-N, 5.34

pv* 1979 Cymaclymenia warsteinensis sp. nov. - Korn, p. 55, pl. 1, figs. 5,6a,b (non figs. 4a-c), non fig. 2.5, non fig. 3.6.

p 1981a Cymaclymenia warsteinensis Korn - Korn, p. 194, figs. 13c-e (non figs. 13a,b) fig. 12a (non figs. 12b,c).

Material: Besides examining numerous specimens in Korn's own collection there were two more available for study. These are HU P82.5 (Pl. 5.39, Figs. 4-6, Textfigs. 5.33L,M), from Effenberg, and SM H7534 (Pl. 5.39, Figs. 1,7,8, Textfig. 5.33N) collected by Münster, from Schübelhammer, Oberfranken.

Diagnosis: Cymaclymenia with narrow umbilicus amounting in mature specimens to 25% of the diameter, compressed whorl section with converging flanks, and narrow rounded venter, and fine closely spaced concave prorsiradiate growth-lines.

Description: The specimen from Effenberg is evolute, with an umbilical width decreasing from 40% of the diameter in early whorls to 27% of the diameter at 15mm. The whorl section (Textfig. 5.33L), subcircular in early whorls, quickly becomes compressed with a maximum width near the umbilical shoulder, and flanks converging on a narrow rounded venter. The growth-lines (Textfig. 5.33M) are prorsiradiate, concave, with a prominent ventro-lateral salient and a deep U-shaped ventral sinus.

The larger specimen, SM H7534, has a similar whorl section (Pl. 5.39, Figs. 1,7,8, Textfig. 5.33N) and concave growth-lines numbering 20 per centimetre, are still present at the maximum diameter of 36mm, suggesting that their shape does not change in more mature specimens. The suture of neither specimen is known.

Dimensions:

	D	U	WW	WH	A
SM H7534	36	7.8	6.6	9.2	
HU P82.5	13.9	3.88	3.72	6.18	4.46
	8.95	2.81	2.50	3.81	3.11
	5.82	2.05	1.76	2.36	2.06
	3.74	1.56	1.24	1.41	1.41
GPI 62-3, _fide_	17.4	4.8	5.2	7.7	
Korn 1981a,p.193	10.8	3.4	4.0	4.6	

Discussion: The specimen described here in detail was collected from Effenberg and identified by Korn as _Cyma_. _warsteinensis_. Nearly all of the paratype material of _Cyma_. _warsteinensis_, including the figured specimens, came from this same locality. None of these specimens, however, resembles the holotype of _Cyma_. _warsteinensis_, which was collected from Bilsteinhöhle (see Chapter 7) and is assigned to _Cyma_. _semistriata_ (see below). The principal differences between the two species lie in the whorl cross-sectional shape and growth-line form.

The specimen from the Münster Collection at Cambridge was associated with the label Cl. plana. According to Münster (1832) this variety had an almost smooth shell and was illustrated (pl. III, fig. 5) with concave, prorsiradiate growth-lines. The illustrated specimen cannot now be traced. Gümbel (1863, pl. XVIII, fig. 3a,b) figured another example (possibly the original, although this was not stated) which, by contrast, had biconvex, rursiradiate growth-lines. In the absence of any convincing type material and recognising that Münster's description and figure are brief and ambiguous, Planulites planus Münster 1832 is considered a nomen dubium.

Horizon and distribution: Specimens are known from the Sauerland and Oberfranken, and according to Korn the species was encountered in the subarmata Zone.

Cymaclymenia sp. b

Pl. 5.42, Figs. 3,7,8,10,11, Textfigs. 5.33E-G

Material: SM H10406, collected by Münster from Schübelhammer, Oberfranken, labelled as Cl. semistriata.
Diagnosis: Cymaclymenia, lacking strong ribs, with an umbilicus amounting to 25% of the diameter, and having fine closely spaced (45 per centimetre) concave prorsiradiate growth-lines, at a diameter of 30mm.

Description: This specimen is illustrated in Pl. 5.42, and Textfigs. 5.33E-G. The shell form is compressed with flanks converging from a maximum width at the umbilicus towards a rounded venter. The internal mould of the venter is bounded by shallow grooves, by a diameter of 30mm. At a diameter of 45mm the ratio: U/D and WW/WH are 0.25 and 0.66, respectively.

The growth-lines are concave, prorsiradiate, with a U-shaped sinus over the venter. They number 45 per centimetre at a diameter of 30mm, and are bunched into groups of 5 or 6 near to the umbilical shoulder, forming very weak ribs which run slightly forwards, but not far enough to be considered as biconvex.

The body chamber is preserved through 100^o, and the presence of a wrinkle-layer keel on the venter, and umbilical seam suggest that it formerly extended to 180^o. Four concave asymmetric constrictions are visible on the body chamber. They diminish in depth and have their steeper flank towards the former aperture. The suture is illustrated in Textfig. 5.33F.

Dimensions:

	D	U	WW	WH	A
SM H10406	43	10.3	12.6	19.1	13.6
	28.8	7.67	8.7	13.6	9.5
	19.7	5.82	5.16	8.2	5.82

Comaprisons: Cyma. aff. serpentina is the most similar species. This has truly biconvex growth-lines and the apex to the ventro-lateral salient lies on the flank, rather than on the ventro-lateral shoulder.

Horizon and distribution: Only this specimen, presumably from the Clymenia Stufe of Schübelhammer, is known.

Cymaclymenia serpentina Schmidt 1924

Pl. 5.40, Figs. 14,15, Textfig. 5.33K

* 1924 Cymaclymenia striata var. serpentina var. nov. - Schmidt, p. 131, pl. 7, fig. 3.

Type material: The specimen figured by Schmidt has not been located in Berlin, its stated repository.
Material: A single unnumbered, distorted specimen in the Münster Collection at the University of Erlangen-Nürnberg.
Diagnosis: Cymaclymenia with narrow umbilicus amounting to 25% of the diameter at a diameter of 45mm, and strongly biconvex, sickle-shaped growth-lines with a prominent rounded ventro-lateral salient.

Description: Illustrated in Pl. 5.40, Figs. 14,15 is the single specimen assigned to this species. It clearly shows the narrow umbilicus, steep umbilical walls and well defined umbilical shoulder. The flanks are flattened and converging and the venter flattened also. The sickle-shaped growth-lines are illustrated in Textfig. 5.33K.

Discussion: The specimen Schmidt figured was from Dasberg, yet this locality was not listed in his account of the species which mentions Üllendahl, Beil and Wildungen.

Comparisons: No other species of Cymaclymenia has such a prominent rounded ventro-lateral salient. Cymaclymenia aff. serpentina, described below, has an angular salient whereas here it is rounded.

Dimensions:

	D	U	WW	WH
UEN, Pl.5.40, Figs. 14,15.	32.3	5.3	10.4	15.7

Horizon and distribution: Schmidt's specimens probably came from the Clymenia Stufe, especially the specimen he reported from Beil, where no levels higher than the middle Clymenia Stufe are known.

Cymaclymenia aff. serpentina Schmidt 1924

Pl. 5.40, Figs. 6,7

1960 Cymaclymenia cordata Wedekind - Selwood, pl. 27, fig. 5.

Material: An unnumbered specimen in the Museum für Naturkunde, Berlin, collected by Denckmann from Langenholthausen, and figured by Schmidt (1924, pl. 7, fig. 2).

Diagnosis: This specimen is distinguished by its narrow umbilicus amounting to only 25% of the diameter at a diameter of 35mm, and biconvex growth-lines, with a prominent angular ventro-lateral salient.

Description: Little can be added to the diagnosis of this specimen, illustrated in Pl. 5.40, Figs. 6,7. Growth-lines are closely spaced, numbering about 80 per centimetre at a diameter of 35mm, and are bunched over the low ribs formed near to the umbilicus.

Dimensions:

	D	U	WW	WH
Pl.5.40,Figs.6,7.	35.7	8.4	ca12	16

Discussion: This specimen closely resembles the specimen figured by Selwood (1960, pl. 27, fig. 5), recorded as from the lower faunal division (endogona Subzone) of the Wocklumeria Stufe.

Horizon and distribution: The species is known only from the two occurrences mentioned above.

dorsocostata Group

Cymaclymenia dorsocostata (Münster 1840)

Pl. 5.39, Figs. 16,17

v* 1840 Clymenia dorsocostata sp. nov. - Münster, p. 93, pl. XVI, figs. 5a-b.

pv 1863 Clymenia dorsocostata Münster - Gümbel, p. 146, pl. XVIII, figs. 4a-c (refiguring of the holotype).

? 1921 Cymaclymenia dorsocostata Münster - Schmidt, p. 288.

1924 Cymaclymenia dorsocostata Münster - Schmidt, p. 131.

1981a Cymaclymenia dorsocostata Münster - Korn, p. 202, figs. 22a,b,c (refiguring of the holotype).

Type material: The single specimen, BSP AS VII 557, collected by Münster (1840) from Schubelhammer, is identified as the holotype.
Diagnosis: Coarsely ribbed Cymaclymenia, with a compressed whorl section, umbilical width amounting to 30% of the diameter, and weakly concave, prorsiradiate growth-lines with a shallow sinus over the venter, parallel to which run coarse ribs.

Description: Only the holotype (BSP AS VII 557) is known to me. This is a relatively large, but poorly preserved specimen. Between diameters of 27 and 37mm it has an umbilical width amounting to 30% of the diameter. During the last half-whorl preserved the ratio WW/WH decreases from 0.8 to 0.6, as the body chamber becomes more compressed.

Growth-lines, described above, are visible only on a small area of shell at a diameter of ca 28mm. Weak ribs are present on the flanks, parallel with the concave growth-lines, and during the last half whorl these become much stronger near the ventro-lateral shoulder (where some appear to bifurcate), and over the flatly rounded venter. There is a shallow ventral sinus. The ribbing is equally prominent on the internal mould and shell.

The polished suture is identifiable only as of the *Cymaclymenia*-type.

Dimensions:

	D	U	WW	WH	A
Holotype, BSP AS	37.7	ca11.5	10.2	ca17	13
VII 557	27	9.8	9.1	11.1	

Discussion: This specimen is interpreted as the holotype since it resembles Münster's figure (although reversed). The shallow furrows marginal to the venter as present in Gümbel's figure 4b are not visible.

The specimen mentioned by Schmidt was not large enough for him to certainly assign it to this species. The only other example of the species was figured by Korn (1979, 1981a, fig. 22c) where in ventral view ribs with a shallow sinus can be seen.

Horizon and distribution: The holotype comes from an unknown level at Schübelhammer, Oberfranken, and Korn's specimen came from the lower *Wocklumeria* Stufe at Effenberg.

Cymaclymenia *semistriata* (Münster 1832)

Pl. 5.39, Figs. 9-15,18,19

(?) 1832 *Ammonites semistriatus* sp. nov. - von Buch, p. 179, pl. III, fig. 12.

v* 1832 *Planulites* *striatus* var. *semistriatus* sp. nov. - Münster, p. 14, pl. III, fig. 4.

1834 *Clymenia* *striata* var. *semistriata* Münster - Münster, p. 76, pl. III, fig. 4 (translation of Münster 1832).

1843 *Clymenia* *striata* var. *semistriata* Münster - Münster, p. 39, pl. IIIa, fig. 4 (copy of Münster 1832).

vp 1863 *Clymenia* *striata* Münster - Gümbel, p. 145, pl. XVIII, fig. 5.

p 1979 Cymaclymenia warsteinensis sp. nov. - Korn, p. 55, pl. 1, figs. 4a,b, figs. 2.5, 3.6, only.

p 1981a Cymaclymenia striata Münster - Korn, p. 187, fig. 11c,d (refiguring of the lectotype).

p 1981a Cymaclymenia warsteinensis Korn - Korn, p. 192, figs. 13a,b, only.

Type material: BSP AS VII 560, collected by Münster from Schübelhammer, Oberfranken, is proposed as the lectotype.
Diagnosis: Cymaclymenia with compressed shell form, subparallel flanks, umbilical width amounting to 27% of the diameter in mature specimens, and widely spaced concave growth lirae which are visible at the ventro-lateral shoulder, and form a U-shaped sinus over the flattened venter.

Description: Three specimens are available for description, the lectotype, BSP AS VII 560, SM H10416 and an unnumbered specimen in the Museum für Naturkunde, Berlin. All were collected by Münster from Schübelhammer, Oberfranken.

The lectotype (Pl. 5.39, Figs. 18,19), described in detail in the diagnosis, is a poorly preserved internal mould; one side is entirely lacking in ornament and the other filed in parts to reveal the suture, has only a few remnants of featureless replaced shell remaining. The shell form is evolute, with the ratio U/D amounting to 0.27 at a diameter of 38mm. The whorl section is compressed with subparallel flattened flanks, and a flattened venter. Traces of ornament remain only on the internal mould of the body chamber, itself just over 180° in length. Near the ventro-lateral shoulder there are impressions of the ventro-lateral salients of apparently rib-like, concave growth-lirae. These continue to form a U-shaped sinus over the venter. Running over the flanks are a number of chevron shaped asymmetric grooves, constrictions of the body chamber caused by thickening of the shell. These are more closely spaced in the last quarter whorl, which feature is taken to indicate that this particular specimen was approaching maturity.

The other two better preserved specimens are smaller than the lectotype (Pl. 5.39, Figs. 9-15). Both specimens are evolute with an umbilical width amounting to 35% of the diameter, at a diameter of 20mm. The compressed whorl section of SM H10416, with rounded converging flanks and rounded venter is illustrated in Textfig. 5.33D.

Widely spaced concave prorsiradiate growth-lines, developed as rib-like lirae, with a prominent ventro-lateral sinus (Textfig. 5.33A), number seven per centimetre at a diameter of ca 20mm on the internal mould, near to and over the venter, and shallow broad ribs are visible near the umbilicus, especially on the larger Berlin specimen. The body chamber of both specimens exceeds 180^{o} in length, and over the last quarter of the whorl the growth-lirae become less pronounced, and approximated, with a more prominent ventro-lateral salient.

Sutures are visible on both specimens; that of SM H10416 is shown in Textfig. 5.33C, and is characterised by a high ventral saddle and a pointed triangular lateral lobe. By contrast the lateral lobe of the Berlin specimen appears more quadrate, with parallel sides.

Dimensions:

	D	U	WW	WH	A
BSP AS VII 560 lectotype.	38.4	ca10.2	ca 9.8	ca17.4	ca12
SM H10416	26.0	9.5	7.3	10.1	
	18.8	7.0	5.9	7.4	
MfN Pl.5.39,Figs. 9,10.	22	ca7.9	5.3	7.9	

Comparisons: These specimens, each differing slightly (see below) closely resemble Cyma. dorsocostata, but differ from it by lacking fine growth-lines between the rib-like lirae, and have a relatively deeper ventral sinus.

Discussion: The obvious similarity between these three specimens, and the main reason for grouping them together, is the shape and rib-like nature of the coarse growth lirae, especially in the way they are expressed on the internal mould near to and over the venter. There are differences between the specimens, noticeably the presence of constrictions, the more closely spaced growth-lirae, and the narrower umbilicus on the lectotype. These, however, may all be explained by its greater size.

Cymaclymenia warsteinensis is probably synonymous with this species. Korn (1979, 1981a) introduced the name using as his holotype a specimen from Bilsteinhöhle, preserved as a silicified internal mould, lacking growth-lines. His illustrations show that it closely resembles SM H10416. There are closely spaced ribs/lirae visible only near to and over the venter, with a moderately deep ventral sinus.

Korn examined only two specimens from the type locality (1979, p. 55), but all of his other paratype material (15 specimens) came from Effenberg. This material (see Cyma. sp. a above) was preserved complete with shell, showing fine closely spaced concave growth-lines numbering about 40 per centimetre on the venter at a diameter of ca 15mm (1981a, fig. 13c,d). By contrast the holotype (1981a, fig. 13b) has only about 15 ribs/lirae per centimetre at a similar diameter. Such a frequency is comparable with that on the specimens from Schübelhammer described above.

Growth curves for Cyma. sp. a, dorsocostata, semistriata and warsteinensis are plotted in Textfig. 5.34. Here the holotype of Cyma. warsteinensis plots consistently in the fields occupied by Cyma. dorsocostata and semistriata, and the paratype (GPI 62.3, the only one for which measurements are available) plots with Cyma.

sp. a.

Elsewhere (Korn 1981a) included the lectotype of Cyma. semi-striata in synonymy with Cyma. striata. However, the nature of the growth-lines and the more compressed shell form distinguish it from both Cyma. striata sensu Korn and Cyma. striata, as it is redefined here.

Horizon and distribution: The horizon of the material collected by Münster is unknown. Korn stated (1981a) that the holotype of Cyma. warsteinensis came from the subarmata Zone. Specimens are known from the Sauerland and Oberfranken.

costellata Group

An introduction to the taxonomic maze of the remaining ribbed species of Cymaclymenia is necessary. The following specific names have been used in this context: costellata Münster, compressa Münster, costata Wedekind, cordata Wedekind, and, of course, striata Münster. The first name, established in 1832, had lain dormant until revived by Korn (1981a). It is believed that a lectotype has been identified for this species, and it is duly described below.

Wedekind established costata as a species of Varioclymenia in 1908. Later (1914) he recognised that it was a Cymaclymenia. The lectotype (proposed here), from the delphinus Zone at Enkeberg, was figured by Korn (1981a, fig. 6d), and it appears to closely resemble costellata. In 1914 Wedekind established cordata, another species of Cymaclymenia, for examples from the Clymenia Stufe, which in contrast to costata had biconvex growth-lines, a narrower lateral lobe and a higher ventral saddle. He considered them both to be distinguished from Cyma. striata var. costellata by their ribs, which were confined to the umbilical region. Type material for cordata cannot now be traced. The better preserved specimen which he figured (pl. II, figs. 13a-c) is proposed as the lectotype. This was collected by Torley from Hövel. Torley's Collection passed on his death to several museums and a search at two of these, Ruhrland Museum Essen and Staatsmuseum Menden, revealed a single specimen labelled as cordata (RE 551 734.5 A131/2; Pl. 5.40, Fig. 9) and this seems indistinguishable from the lectotype of cordata.

Schindewolf (1923a) revised the species of Cymaclymenia and placed costellata and striata in synonymy in his group I.1. Characterised by lack of ribbing, cordata was put in synonymy with compressa, using as an example of that species a specimen figured by Gümbel (1863, pl. XVIII, figs. 6a-c).

Subsequently Lange (1929), Matern (1931) and Korn (1979) have all used compressa as the valid senior synonym of cordata Wedekind. However, a careful reading of Münster's and Schindewolf's accounts shows that this was an incorrect decision.

Münster's figure (1832, pl. 1, figs. 4a-c) shows a compressed subinvolute specimen with a Cyrtoclymenia-type external suture, and his description confirms this impression. Gümbel (1863) failed to discuss the smaller specimen he figured as compressa, shown with a Cymaclymenia suture (pl. XVIII, fig. 6). Later Schindewolf (1923a) stated that a comparison between compressa and cordata was difficult. He acknowledged that there were major differences between the interpretations of Münster and Gümbel, but explained these away as Münster's errors, and then proceded to find errors in the way Gümbel had figured the specimen. Today, neither Münster's nor Gümbel's specimens can be located.

Clearly the correct interpretation of this conflicting account is to regard Planulites/Clymenia compressus/a Münster as ?Cyrtoclymenia sp. and a nomen dubium, since there is no trace of type material. Clymenia compressa Gümbel is simply a junior homonym of Cl. compressa Münster, and thus invalid.

Korn considered that he had identified the holotype of compressa in Munich. I saw there three specimens associated with a compressa label, but like Gümbel etc. I thought none resembled Münster's figure. Regardless of the fact that Korn's holotype had neither whorl outline, nor sculpture preserved, he placed it in synonymy with costellata, with which opinion I cannot concur.

Inconclusion, there are three valid specific names for ribbed species of Cymaclymenia, costellata, costata and cordata, of which the first two are considered as synonyms, and the third less well known species may be so too.

Cymaclymenia costellata (Münster 1832)

Pl. 5.40, Fig. 11, Pl. 5.41, Figs. 1,2,7-13

v*	1832	Planulites striatus var. costellatus sp. nov. Münster p. 13, pl. III, figs. 2a-c.
	1834	Clymenia striata var. costellata Münster - Münster, p. 75, pl. II, figs. 5a-c (translation of Münster 1832).
	1843	Clymenia striata var. costellata Münster - Münster, p. 9, pl. IIIa, figs. 2a-c (copy of Münster 1832).
vp	1863	Clymenia striata Münster - Gümbel, p. 144, pl. XVIII, figs. 2a-c (refiguring of the holotype).
	1908	Varioclymenia costata sp. nov. - Wedekind, p. 606, pl. XLIV, fig. 3.
	1914	Cymaclymenia costata Wedekind - Wedekind, p. 26, pl. II, fig. 14, pl. V, figs. 1a,b.
?	1914	Cymaclymenia cordata sp. nov. - Wedekind, p. 28, pl. II, figs. 12,13.

p 1923a Cymaclymenia striata Münster - Schindewolf, p. 437.
1924 Cymaclymenia striata Münster - Schmidt, pl. 7, fig. 1.
? 1929 Cymaclymenia compressa Münster - Lange, p. 89.
? 1931 Striatoclymenia compressa Münster - Matern, p. 96.
1981a Cymaclymenia costellata Münster - Korn, p. 185, figs. 6a,b (refiguring of the holotype).

Type material: BSP AS VII 546 from Schübelhammer, Oberfranken, is recognised as the holotype.
Remarks: Münster's catalogue (1833) lists only one specimen of this species. The holotype is clearly the same specimen as that upon which Gümbel's figure was based, and is of the same size as Münster's figure, and thus taken to be the same specimen.
Diagnosis: Cymaclymenia, which by a diameter of 50mm has an umbilical width amounting to 25-30% of the diameter, whorl height:whorl width ratio of approximately 0.65 and pronounced, concave ribs which are strongest near to the umbilicus, and tabulate venter bounded by shallow grooves.

Description: The holotype (Pl. 5.41, Figs. 7,8,10,11) at a diameter of 50mm has an umbilical width:diameter ratio of 0.27, and a whorl width:height ratio of 0.67. Earlier whorls are not visible. Ornament is poorly preserved. A small area of shell at a diameter of ca 40mm shows closely spaced, concave, lirate growth-lines, which are bunched to form weak ribs present only on the umbilicad portion of the flanks. The ventro-lateral salients are prominent. The ornament is modified on the half whorl of body chamber, where ribs are visible on the internal mould, running right across the flank. The ribs are broader and more widely spaced on the last quarter whorl. Faint impressions of the lirae can be seen on the internal mould of the body chamber at the ventro-lateral shoulder and one can be traced as a shallow sinus over the venter. The venter, rounded on the phragmacone, becomes tabulate on the body chamber, and bounded by shallow grooves.

An unnumbered specimen in the Museum für Naturkunde, Berlin, (Pl. 5.40, Fig. 11) collected by Denckmann from Wettmarsen, and figured by Schmidt (1924, pl. 7, fig. 1) can be included in this species. This shows concave ribs on the internal mould of a body chamber, which develops a tabulate venter. It also shows what may have been an apertural modification, where at the maximum diameter preserved, there is a concave prorsiradiate constriction followed by a ridge, representing a groove in the former shell, or a widening of the aperture, extended laterally by flares.

Dimensions:

	D	U	WW	WH
BSP AS VII 546 holotype.	51.2	14	15	22.2
Pl.5.40, Fig.11.	49.8	14	13.2	21.0

Discussion: This species name has long lain unused in the literature. Only Wedekind (1914) has considered it, but he referred no material to it. However, the identification of the holotype with the original figure (Münster 1832) seems quite unambiguous and so the species must be revived. Korn (1981a) reached similar conclusions.

Less certain is the relationship of the ribbed species of Cymaclymenia described by other authors, especially Wedekind, to costellata. He stated what the distinction between costellata, costata and cordata was (see above). I have not had the benefit of examining Wedekind's material, because his material was not available for study when I visited Göttingen, and photographs of the specimens have had to suffice.

The lectotype of Cyma. costata (proposed here as GPIG 390:39) is preserved well enough to show the development of a tabular venter, bounded by grooves, at a diameter of approximately 50mm. Concave radial ribs, strongest at the umbilicus and extending across the flank are visible at a diameter of 40mm. These diminish in strength on the body chamber where there are equally spaced growth-lines. These features are all present on costellata, except that there the ventro-lateral growth-line salient is stronger. The two type specimens are considered to be conspecific.

Wedekind's illustrations (1914, pl. VI, figs. 12,13) of Cyma. cordata are poor, and in the absence of the specimens there is nothing to corroborate his descriptions. He considered the growth-lines to be biconvex, yet they appear to be no different from those on the lectotype of costata, which he regarded as concave. His other distinguishing criterion between the two species was the extent of the ribbing across the flank. Certainly his photograph shows the ribs on cordata to be strongest near the umbilicus, and to fade on the ventrad portion of the flank, but they are by no means confined to the umbilicus as he suggested, and only little different from costata. Wedekind also recognised a significant difference in the relatively broad lateral lobe of costata and the narrow, pointed lateral lobe of cordata. Nothing is known of the intraspecific variations of sutures of Cymaclymenia, nor the importance of interspecific differences. In conclusion cordata and costellata are provisionally regarded as conspecific. In any case the absence of type material would make it unwise of any author to use the specific name.

Cymaclymenia aff. costellata (Münster 1832)

Pl. 5.40, Fig. 9, Pl. 5.41, Figs. 1-6,12-14

Material: Six specimens, mostly incomplete:

UEN 88	Münster Collection	Schübelhammer	Pl.5.41, Figs.5,6.

UEN 89	Münster Collection	Schübelhammer	Pl.5.41 Figs. 12-14.
SM H7530	Münster Collection	Schübelhammer	Pl. 5.41, Figs. 1,2.
SM H7531	Münster Collection	Schübelhammer	Pl.5.41, Figs. 3,4.
RE 551 734.5 A131/2	Torley Collection	Hövel	Pl. 5.41, Figs. 9.
MfN	von Buch Collection	Dzikowiec	Pl. 5.41, Figs. 9.

Description: All of these specimens appear to bear a relationship to Cyma. costellata. The minor differences between them will be stated, but since stratigraphic control of the specimens is lacking their significance cannot be evaluated.

UEN 88 and SM H7530 both have very shallow, concave ribs (Pl. 5.41, Figs. 1,2,5,6). The whorl section is compressed with weakly converging flattened flanks. The venter, flattened on SM H7530, develops a pair of ventro-lateral furrows more clearly seen on UEN 88. The growth-lines are closely, equally spaced; numbering 30 per centimetre on UEN 88 and 35 per centimetre on SM H7530 at a whorl height of 16 and 20mm respectively. The ribs, numbering 36 per whorl on SM H7530 are more strongly developed on the internal mould and near to the umbilicus.

SM H7531 (Pl. 5.41, Figs. 3,4) is a small fragment of roughly the same dimensions as UEN 88. They are both mature specimens, shown by the approximation of the last few ribs. The venter of H7531 is extremely well preserved. Externally there is a narrow tabulate surface towards which the flanks converge, but internally on the mould are two strong ventro-lateral grooves, and weak ribs on the venter itself. The lirate growth-lines of SM H7531 number 20 per centimetre and differ from other specimens by being biconvex radial with a very shallow mid-flank sinus. Also the growth-lines are clearly bunched near to the umbilicus.

UEN 89 (Pl. 5.41, Figs. 12-14) is a specimen with a compressed quadrate whorl section, well defined umbilical shoulder and a flatly rounded venter, which lacks ventro-lateral grooves, probably because of its small size. The umbilical width amounts to 30% of the diameter at a diameter of 39mm. The growth-lines, expressed as raised lirae, are concave, prorsiradiate with a shallow U-shaped ventral sinus, and number 32 per centimetre at a diameter of 35mm. Actual growth-line spacing is variable but tends to be greater between ribs. The ribs run parallel to the growth-lines; on one side of the shell they are present only near the umbilicus, on the other they are also developed near to the venter. Weak ribs are visible on the internal mould.

RE 551 734.5 A131/2 (Pl. 5.40, Fig. 9) has lirate growth-lines (24 per centimetre) which are grouped in bunches of 5-7, and present only on the ribs, between which the shell is relatively smooth. Both on the internal mould, and shell, the ribs are more strongly developed near to the umbilicus. A ventro-lateral groove is visible on the body chamber.

The specimen (MfN, unnumbered) from Dzikowiec has a narrower umbilicus amounting to only 24% of the diameter at a diameter of 43mm, and a whorl height to whorl width ratio of 0.71 (Pl. 5.41, Fig. 9, figured by Frech 1902, pl. V(IV), fig. 1). The umbilical shoulder is well defined, and the umbilical wall steep. Growth-lines are concave, prorsiradiate, becoming almost biconvex near the aperture where there is a very low salient near the umbilicus. Ribs, running parallel with the growth-lines, increase in strength during the last whorl from being present only near the umbilical shoulder at a whorl height of 11mm, to running almost the whole way across the flank, at a whorl height of 17mm.

The apparent aperture of the shell is marked by a groove on the inner surface of the shell, which does not run parallel with the previous whorl. It is generally concave in shape, but there are strong salients near to the umbilicus and venter where the groove dies away. There seems to be no feature which could be represented by the dotted line on Frech's figure.

Dimensions:

	D	U	WW	WH
UEN 88			15	23
UEN 89	39.2	12.0	14.1	17.5
SM H7530	53.4	14.5	15.4	23.7
SM H7531			15	25
RE 551 734.5 A131/2	66	20.7		26
MfN Pl.5.41,Fig. 9.	43 36.7	10 5.2	14 7.9	19.7 11.2

Horizon and distribution: These specimens were collected widely throughout central Europe, from unknown stratigraphic levels, probably in the Clymenia Stufe.

Cymaclymenia sp. c

Pl. 5.40, Figs. 3-5,10

Material: Two distorted specimens in the Museum für Naturkunde, Berlin, labelled Cymaclymenia recticosta MS, collected by Schindewolf from Hauern, Wildungen.
Diagnosis: Cymaclymenia with fine weakly concave radial lirae and strong blunt ribs, numbering upwards of twenty per whorl.

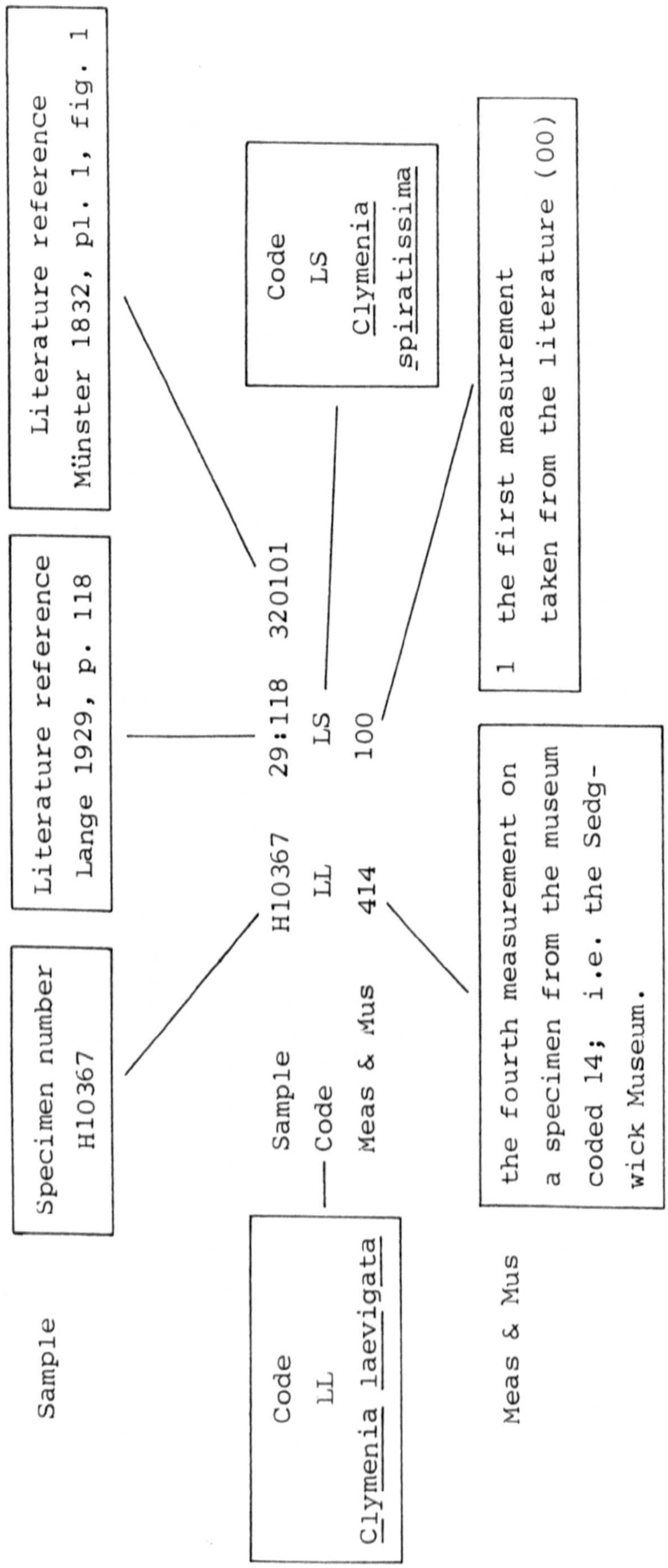
Description: Little needs to be added to the diagnosis. The umbilicus amounts to about one-third of the diameter and the whorl section is slightly compressed, although erosion of one side of each specimen makes assessment difficult (Pl. 5.40, Fig. 3). The growth-lines, concave at a whorl height of 10mm, become flatter at increasing diameters, and are almost straight by a whorl height of

25mm. Coincident with this change growth-line frequency increases from 50 to about 80 per centimetre, and ribs increase in extent from being present only near the umbilical shoulder, to running across the whole width of the flank. Ribs are not present over the broad venter, and the growth-lines form a shallow U-shaped sinus. An eroded Cymaclymenia suture is identifiable on the larger specimen.

Dimensions: Both specimens are distorted and poorly preserved so any measurements are meaningless.

Remarks: These two specimens are unlike any others included within Cymaclymenia, being distinguished by their blunt ribs and growth-lines. They therefore deserve specific distinction.

Horizon and distribution: The horizon of the two described specimens is unknown.



Textfig. 5.35 Explanation of headings used in data lists.

Data used in plotting graphs

Computer print-outs have been used to list the data used to compile the various graphs in the systematic section. A database system and programs developed by R. Middleton, primarily for geochemical analysis in the Geology Department, were used to plot the graphs. Much time was saved by using this sytem and I wish to acknowledge my gratitude to Dick Middleton for his help in this field.

The abbreviations used for the measured parameters are the same as referred to elsewhere in this thesis. Three headings are used to identify each set of data, and these headings need some explanation (Textfig. 5.35). They are:

Sample
Code
Meas & Mus

"Sample" is clear enough, indicating the sample number, but there were only six character-spaces available so some specimen numbers have been truncated. Unnumbered specimens are referred to by the Musem abbreviations used throughout e.g. MfN, Museum für Naturkunde, SM, Sedgwick Museum.

Data taken from publications is identified, somewhat cryptically, in two ways. Measurements taken directly from another author's work have a sample number such as 29:172, where 29 indicates the year of publication (in this case referring to Lange 1929), and 172 is the page number. The publications referred to by the numbers are listed below, but the reader will probably already be familiar with the dates of most relevant works, from reading the systematic descriptions. Where measurements have been taken directly from an illustration a six figure number is used, e.g. 631502. Again the first two numbers refer to a publication, in this case Gümbel 1863. The other numbers indicate plate 15, figure 2. This configuration could be confused with a six figure specimen number, but this possibility can be excluded by reference to the third set of numbers, "Meas & Mus" (see below).

The "Code" refers to the taxonomic name of the specimen. It is intended to be acronymic, and refers to both the genus/subgenus, and species. For example CK indicates Endosiphonites (Costaclymenia) kiliani; SEP Sellaclymenia plana; GGU Genioclymenia (Genioclymenia) speciosa etc. A list of all codes, and their meaning, is given below.

The last set of numbers headed "Meas & Mus" indicates two things. The first figure shows up instances where more than one set of measurements has been taken from the same specimen and its purpose is to ensure that each data set is uniquely identified. Thus 1 indicates the first (usually at maximum size) set of readings taken, and 9 the ninth set. The second and third figures show from where the specimen has come. A series of numbers from 1-20 refer to particular museums, and are listed below. "00" indicates that the particular data set was taken from the literature.

Museum Codes

00	No museum - literature reference
01	British Museum (NH), London
02	Bayerische Staatssammlung, Munich
03	Bristol University
04	Universität Erlangen-Nürnberg
05	Ruhrland Museum, Essen

06 Geol. Pal. Institut, Göttingen
07 Geological Survey Museum, IGS, London
08 Hull University
09 Nordrhein Westphalen Geologische Landesamt
10 Fachbereich Geowissenschaft, Marburg
11 Staatsmuseum, Menden
12 Museum für Naturkunde, Berlin
13 Senckenberg Museum, Frankfurt
14 Sedgwick Museum, Cambridge
15 M. R. House Collection
16 D. Korn Collection, Sundern
17 J. D. Price Collection
18 K. Wunderlich Collection, Leverkusen
19 G. Trost Collection, Düsseldorf
20 Wiesbaden Museum

Abbreviated Literature References

03 Tokarenko 1903
08 Wedekind 1908
10 Rzehak 1910
14 Wedekind 1914
23 Schindewolf 1923a
29 Lange 1929
32 Münster 1832
38 Müller 1938
39 Münster 1839
48 Richter 1848
52 M'Coy 1852
56 Müller 1956
60 Petter 1960
63 Gümbel 1863
75 Petersen 1975
92 Loewinson-Lessing 1892

Full details can be found in the section headed References.

Taxonomic Abbreviations

Section 1

BB Biloclymenia bilobata
BL Biloclymenia laevis
B1 Biloclymenia sp. (2091)
B2 Biloclymenia sp. (MfN, Pl. 5.11, Fig. 10
B3 Biloclymenia sp. (AS VII 524, 525)

CAC Carinoclymenia beuelensis

CB Endosiphonites (Costaclymenia) binodosa
CE Endosiphonites (Costaclymenia) enodis
CK Endosiphonites (Costaclymenia) kiliani
CM Endosiphonites (Costaclymenia) muensteri

CMA Cymaclymenia sp. b
CMB Cymaclymenia barbarae and aff. barbarae
CMC Cymaclymenia camerata
CMD Cymaclymenia dorsocostata
CME Cymaclymenia evoluta
CMF Cymaclymenia aff. dorsocostata
CMG Cymaclymenia sp. a
CMI Cymaclymenia involvens
CMN Cymaclymenia aff. costata
CMO Cymaclymenia costata
CMS Cymaclymenia striata
CMT Cymaclymenia aff. striata
CMW Cymaclymenia semistriata

CY Cyrtoclymenia
CYA Cyrtoclymenia angustiseptata
CYC Cyrtoclymenia crassa
CYI Cyrtoclymenia involuta
CYP Cyrtoclymenia plicata
CYS Cyrtoclymenia subnodosa

DA Gen. Nov. D arietina
DAC Gen. Nov. D acuta
DF Gen. Nov. D flexuosa

DK Gen. Nov. D kayseri
D1 Gen. Nov. D sp. (2015)
D2 Gen. Nov. D sp. (2076)

EA Gen. Nov. E sp. a
EB Gen. Nov. E sp. b

FC Gen. Nov. F costata
FF Gen. Nov. F falcifera
FST Gen. Nov. F stuckenbergi
FSU Gen. Nov. F subflexuosa

GE Genuclymenia sp.
GEA Genuclymenia angelini
GEB Genuclymenia borni
GED Genuclymenia discoidalis
GEF Genuclymenia frechi
GEG Genuclymenia guembeli
GEK Genuclymenia karpinskii

GG Gonioclymenia (Gonioclymenia) SM H10407
GGP Gonioclymenia (Gonioclymenia) praematura
GGS Gonioclymenia (Gonioclymenia) speciosa
GGU Gonioclymenia (Gonioclymenia) subcarinata

GKI Gonioclymenia (Kalloclymenia) insignis
GKC Gonioclymenia (Kalloclymenia) crassa
GKD Gonioclymenia (Kalloclymenia) dasbergensis
GKP Gonioclymenia (Kalloclymenia) pessoides
GKS Gonioclymenia (Kalloclymenia) subarmata
GKU Gonioclymenia (Kalloclymenia) uhligi

GNA Gonioclymenia (Subgen. Nov. A) sp. a
GNB Gonioclymenia (Subgen. Nov. A) brevispina
GNF Gonioclymenia (Subgen. Nov. A) frechi
GNW Gonioclymenia (Subgen. Nov. B) wocklumeri

KI Kosmoclymenia inaequistriata
KS Kosmoclymenia subundulata
KU Kosmoclymenia undulata

L's See section 2

OO _Ornatoclymenia ornata_

PIP _Piriclymenia piriformis_

PLC _Platyclymenia_ (_Pleuroclymenia_) _crassissima_
PPA _Platyclymenia_ (_Platyclymenia_) _annulata_
PPC _Platyclymenia_ (_Platyclymenia_) _crassa_
PPN _Platyclymenia_ (_Platyclymenia_) _nodosa_
PPP _Platyclymenia_ (_Platyclymenia_) _prorsostriata_
PPR _Platyclymenia_ (_Platyclymenia_) _richteri_
PPS _Platyclymenia_ (_Platyclymenia_) _subnautilina_
PPQ _Platyclymenia_ (_Platyclymenia_) _quenstedti_

PRD _Protoxyclymenia dunkeri_
PRS _Protoxyclymenia serpentina_

PT _Platyclymenia_ sp.

PTE _Protactoclymenia euryomphala_
PTK _Protactoclymenia enkebergensis_
PTN _Protactoclymenia steinmanni_
PTO _Protactoclymenia posterior_
PTP _Protactoclymenia pulcherrima_

PTS _Platyclymenia_ (_Trigonoclymenia_) _spinosa_

SE _Sellaclymenia_ sp.
SEP _Sellaclymenia plana_
SET _Sellaclymenia torleyi_

SPI _Sphenoclymenia intermedia_

SUS _Sulcoclymenia sulcata_

Section 2 _Clymenia_

LC _Clymenia crassoides_
LI _Clymenia_ aff. _spiratissima_
LL _Clymenia laevigata_

LN *Clymenia cingulata*

LS *Clymenia spiratissima*

Section 3 *Platyclymenia*

See explanation to Textfig. 5.13.

Section 1

Sample	VII594	VII594	VII589	VII589	2041	A124	A254	A254	c596	c596	VII552	VII552	MFN	MFN	H4010	H4010	VII587	VII587
Code	SEP	SEP	SEP	SEP	SEP	SET	SET	SET	SET	SET	SE	SE	CE	CE	CM	CM	CK	CK
Mus & meas	102	202	102	202	119	105	105	205	112	212	102	202	112	212	114	214	102	202
D	80.50	75.70	43.30	34.50	53.30	36.50	55.90	37.90	56.10	51.00	23.80	17.80	72.00	37.00	97.80	73.00	48.90	35.20
U	28.00	27.00	17.80	13.10	21.50	16.60	25.30	18.00	22.70	21.30	10.50	7.90	30.00	21.70	40.40	32.80	24.90	18.60
WW	17.00	15.00	5.00	4.50	13.00	8.00	10.40	10.00	12.30	11.00	5.50	3.90	0.00	7.10	15.90	11.80	8.00	6.90
WH	32.20	30.00	17.80	12.00	21.00	12.40	18.70	n.m.	20.00	18.90	8.70	n.m.	28.00	11.60	36.00	25.70	13.40	9.50

Sample	VII590	VII590	H10385	H10385	H10385	H10385	140604	29:73	MFN:NT	2078	2091	2091	2091	2091	2091	2091	2091	2091
Code	CK	CK	CK	CK	CK	CK	CK	CK	CB	CB	B1	B1	B1	B1	B1	B1	B1	B1
Mus & meas	102	202	114	214	314	414	100	100	112	118	118	218	318	418	518	618	718	818
D	60.80	47.80	n.m.	n.m.	n.m.	n.m.	52.00	65.00	60.00	66.00	69.00	64.50	45.40	42.40	32.50	22.40	15.90	11.00
U	29.40	23.30	n.m.	n.m.	n.m.	n.m.	27.00	31.00	31.50	30.50	14.70	13.20	8.90	10.40	6.50	4.70	3.10	2.10
WW	11.00	8.80	13.00	7.60	5.00	2.00	5.00	14.50	n.m.	13.00	20.20	20.00	18.50	16.80	12.40	9.90	7.10	5.40
WH	19.00	14.70	18.00	9.50	3.20	3.50	12.50	20.00	16.20	19.00	31.00	28.40	20.00	20.90	15.60	10.40	7.40	5.20

Sample	2091	MFN	MFN	390206	631904	VII524	VII525	480381	VII538	VII538	VII538	BSP:LT	BSP:LT	VII596	A256	A256	H10407	H10407
Code	B1	B2	B2	BB	BB	B3	B3	BL	6GS	6GS	6GS	6GS	6GS	6GU	6GP	6GP	6G	6G
Mus & meas	918	112	212	100	100	102	102	100	102	202	302	102	202	102	105	205	114	214
D	7.60	34.50	26.20	26.30	25.20	11.10	n.m.	20.00	107.70	83.20	77.20	150.00	114.00	99.00	108.00	78.00	70.00	51.00
U	1.20	6.10	5.00	6.00	7.50	3.80	n.m.	4.00	45.20	37.40	n.m.	62.10	44.10	41.00	39.50	43.50	27.00	19.20
WW	3.70	6.90	6.10	10.50	11.00	5.50	4.40	8.50	22.00	16.50	15.20	38.00	25.00	22.00	27.30	22.00	16.50	12.00
WH	3.50	17.30	13.00	13.00	12.00	4.35	3.50	8.50	38.00	27.50	26.20	51.50	42.10	36.00	40.70	29.50	26.00	19.00

Sample	H10407	VII537	VII537	H10394	H10394	H10394	H10394	H10394	320602	320602	MFN:LT	MFN:LT	A255	A255	7083	7083	c550	c550
Code	6G	6KS	6KS	6KS	6KS	6KS	6KS	6KS	6KS	6KS	6KB	6KP	6KC	6KC	6KI	6KI	6KU	6KU
Mus & meas	314	102	202	114	214	314	414	514	100	200	112	112	105	205	107	207	112	212
D	30.00	100.40	69.00	104.00	76.00	55.20	39.50	27.90	180.00	140.00	42.00	31.20	52.00	36.00	61.00	46.50	68.50	54.50
U	0.00	54.40	37.50	53.00	38.80	27.50	18.90	0.00	96.00	35.00	20.80	17.90	23.60	0.00	32.40	24.00	32.00	24.00
WW	5.00	20.00	14.50	22.50	17.70	12.70	9.10	5.40	32.00	0.00	12.20	8.20	14.20	10.20	0.00	9.00	19.00	18.90
WH	11.00	24.50	18.00	29.50	21.00	16.00	11.80	9.00	24.50	16.00	12.50	7.50	16.20	12.20	16.70	12.50	22.00	15.70

Sample	14:67	MFN:LT	MFN:LT	MFN	MFN:HT	MFN:HT	H10373	H10373	H10373	H10373	VII586	VII586	H10397	14:34	P82.3	P82.3	3126	3126
Code	6KD	6NF	6NF	6NB	6NW	6NW	6NA	6NA	6NA	6NA	SPI	SPI	SPI	PPR	PPR	PPR	PPR	PPR
Mus & meas	100	112	212	112	112	212	114	214	314	414	102	202	114	100	108	208	110	210
D	50.00	71.60	59.20	34.40	45.00	n.m.	140.00	92.00	58.00	38.00	126.00	88.00	0.00	60.00	37.20	29.80	33.40	29.20
U	21.00	39.30	30.00	14.20	17.00	n.m.	50.50	34.00	22.50	0.00	57.10	38.00	0.00	27.70	17.20	13.80	15.20	13.60
WW	13.00	14.40	11.20	4.10	10.00	6.50	31.40	20.00	12.50	8.00	21.50	17.00	22.30	17.70	11.90	9.20	8.40	7.30
WH	18.00	18.40	15.10	11.00	6.80	11.00	51.60	35.00	22.00	12.00	39.50	31.00	44.70	20.00	12.40	9.00	10.80	10.30

Sample	VII600	3152	3153	3153	WSB3	WSB2	WSB2	WSB1	3128	3127	3125	3125	3125	3125	3154	3154	3154	3154
Code	PPN	PPK	PPB	PPB	PPS	PPS	PPS	PPS	PPC	PPP	PPA	PPA	PPA	PPA	PLC	PLC	PLC	PLC
Mus & meas	102	110	110	210	120	120	220	120	110	110	110	210	310	410	110	210	310	410
D	58.00	32.00	39.00	34.00	59.20	56.30	43.90	66.00	24.80	26.20	28.80	21.50	15.70	10.90	35.70	34.50	25.90	21.20
U	23.40	14.80	18.00	14.50	0.00	26.00	20.10	30.20	10.90	14.30	15.00	11.20	8.90	6.60	15.00	15.50	10.90	6.70
WW	12.80	9.30	10.00	8.00	18.00	0.00	11.40	17.90	5.30	7.00	7.80	5.50	4.50	3.80	15.50	15.10	12.30	11.50
WH	21.40	9.00	12.20	9.90	22.00	19.00	14.20	21.90	7.90	11.00	7.80	5.50	4.40	3.80	12.40	11.60	8.70	6.90

Section 1

Sample	3154	VII598	2064	3129a	P82.1	2065	3129b	P82.2	MFN:LT	MFN:LT	VII550	VII550	VII551	H10382	VII585	VII585	VII599	VII584
Code	PLC	PTS	PTS	SUS	SUS	SUS	SUS	SUS	PIP	PIP	DO	DO	DO	DO	CYA	CYA	CYA	CYP
Mus & meas	510	102	119	110	108	118	110	108	112	212	102	202	102	114	102	202	102	102
D	15.00	44.00	52.00	17.50	13.40	26.00	12.50	14.70	19.10	14.70	26.50	20.60	23.00	22.20	56.40	46.00	56.00	53.00
U	6.50	21.40	24.70	5.40	5.50	11.20	5.80	6.20	8.30	6.20	12.40	8.50	0.00	10.20	14.30	12.70	14.00	17.00
WW	8.90	9.20	13.00	4.00	3.00	0.00	0.00	3.10	3.80	3.50	5.50	6.40	7.00	7.50	17.60	18.00	21.00	21.00
WH	5.00	14.50	17.00	6.30	4.20	8.70	3.20	4.30	5.90	4.70	8.00	7.80	10.00	8.00	23.80	19.50	25.50	21.00

Sample	VII583	VII583	BSP	MFN	MFN	2096	2096	P82.4	P82.4	P82.4	P82.4	P82.4	P82.4	P82.4	P82.4	MFN	14:21	14:21
Code	CYP	CYP	CYS	CY	CY	CYI	CYI	CYI	CYI	CYI	CYI	CYI	CYI	CYI	CYI	CYI	CYI	CYC
Mus & meas	102	202	102	112	112	118	218	108	208	308	408	508	608	708	808	112	100	100
D	45.00	32.70	19.20	0.00	32.20	42.90	35.00	28.20	20.80	14.10	9.40	6.30	4.10	2.80	2.00	27.30	23.00	34.80
U	15.00	10.60	4.90	5.30	0.00	10.00	9.00	5.70	3.80	2.90	2.20	1.80	1.40	1.00	0.70	5.00	5.00	17.30
WW	25.00	16.80	6.80	7.50	13.30	17.40	15.70	11.50	10.00	7.40	4.90	3.30	2.20	1.45	1.05	11.80	10.70	17.00
WH	19.80	16.50	8.00	7.50	14.70	19.60	17.30	12.50	9.80	6.80	4.20	2.90	1.65	1.10	0.80	13.20	12.00	14.60

Sample	14:22	MM	2062	14:31	29:80	14:32	2071	2071	WSB	VII523	MFN:LT	81856	2015	2076	2076	MB6:HT	MB6:HT	VII528
Code	PTP	PTE	PTE	PTK	PTO	PTW	PT	PT	DA	DK	DAC	DF	D1	D2	D2	EA	EA	EB
Mus & meas	100	111	118	100	100	100	118	218	120	102	112	101	119	118	218	110	210	102
D	30.00	37.00	37.00	57.60	61.00	48.80	42.60	30.40	27.00	15.10	31.30	17.80	43.50	75.20	51.50	62.00	40.00	19.50
U	7.50	12.40	11.50	15.00	15.00	16.40	16.10	12.30	9.40	0.00	13.00	4.70	0.00	27.80	20.00	16.60	11.00	5.50
WW	9.40	10.00	11.50	12.00	22.00	15.00	15.00	0.00	0.00	3.60	5.00	0.00	7.30	17.00	0.00	11.50	10.90	4.80
WH	12.50	13.80	15.60	17.50	26.30	20.00	16.50	12.40	10.90	4.50	11.40	8.60	19.50	29.20	19.30	28.00	23.00	8.00

Sample	2016	2016	2016	2016	2058	03:31	03:31	14:23	14:68	VII533	VII606	VII606	VII526	VII526	VII526	VII526	VII526	VII526
Code	FST	FST	FST	FST	FST	FST	FST	FST	FST	FF	FC	FC	FSU	FSU	FSU	FSU	FSU	FSU
Mus & meas	119	219	319	419	218	100	100	100	100	102	102	202	102	202	302	402	502	602
D	20.00	13.70	9.20	6.20	19.80	20.00	15.00	20.50	20.00	10.90	20.30	15.00	21.60	15.90	11.00	7.20	5.20	3.60
U	5.90	3.70	2.20	1.30	5.40	0.00	0.00	6.90	7.00	4.90	5.90	3.80	5.00	4.50	3.44	2.60	1.95	1.39
WW	4.60	3.80	2.70	2.10	5.80	5.50	4.50	5.50	5.40	0.00	4.50	4.00	3.80	3.40	2.65	2.18	1.67	1.85
WH	8.30	5.90	4.30	2.90	7.40	7.50	6.50	8.00	7.20	3.70	8.10	5.80	10.00	6.70	4.70	2.88	1.95	1.30

Sample	3021	VI1527	MFN:HT	MFN:HT	MFN	2070	2070	2021	2023	2023	2023	2023	2023	VII559	VII559	DK	DK	DK
Code	FSU	FSU	CAC	CAC	CAC	CAC	CAC	CAC	CAC	CAC	CAC	CAC	CAC	PRD	PRD	PRD	PRD	PRD
Mus & meas	110	102	112	112	112	118	218	119	119	219	319	419	519	102	202	116	216	316
D	50.50	11.20	40.00	24.20	32.00	46.80	31.20	21.80	14.90	8.90	5.40	3.40	0.00	32.00	23.50	30.00	21.50	15.20
U	11.30	3.70	5.00	3.90	4.50	3.90	3.10	2.50	1.90	1.50	1.20	0.00	0.00	13.90	10.70	13.80	10.10	7.60
WW	11.60	2.90	5.00	0.00	5.50	6.60	5.70	0.00	3.20	2.40	1.50	1.15	0.80	0.00	0.00	6.70	5.40	3.90
WH	23.50	4.40	24.00	13.40	16.50	26.30	17.60	12.40	8.30	5.00	2.80	1.50	0.60	11.80	0.00	9.50	6.90	4.70

Sample	DK	DK	DK	DK	DK	DK	VII538	VII538	VII538	VII538	VII538	VII538	VII538	VII538	2077	c597	c597	H10388
Code	PRD	PRD	PRD	PRD	PRD	PRD	PRS	PRS	PRS	PRS	PRS	PRS	PRS	PRS	PRS	KS	KS	KS
Mus & meas	416	516	616	716	816	916	102	202	302	402	502	602	702	802	118	112	212	114
D	11.00	8.20	6.20	4.70	3.50	2.60	97.00	89.00	67.00	51.50	36.50	27.50	20.00	13.80	67.00	51.20	35.80	32.00
U	5.80	4.40	3.30	2.50	1.80	1.30	47.80	41.50	32.50	34.30	18.10	12.50	8.50	6.00	34.00	20.00	14.40	13.40
WW	2.60	1.90	1.40	1.25	0.98	0.90	15.50	18.00	13.00	12.00	8.50	7.30	5.00	3.80	14.50	13.00	10.50	7.90
WH	3.10	2.20	1.60	1.25	0.92	0.80	25.50	26.00	18.00	14.00	10.00	8.10	6.50	4.80	17.50	18.10	12.50	10.90

Section 1

Sample	H10389	H10389	H10390	H10390	H10390	H10376	H10376	H10376	VII597	3135	MFN	H10377	H10377	MFN	SMF:NT	SMF:NT	SMF:NT	SMF:NT
Code	KS	KS	KS	KS	KS	KI	KI	KI	KI	KI	KI	KI	KI	KI	KU	KU	KU	KU
Mus & meas	114	214	114	214	314	112	212	312	102	110	112	114	214	112	113	213	313	413
D	31.40	23.70	42.50	29.50	20.30	56.40	45.00	32.00	26.50	47.00	50.20	21.20	15.10	56.40	75.00	54.50	40.00	27.80
U	13.30	9.60	17.00	11.50	8.40	23.30	18.80	13.20	11.80	19.80	21.80	8.80	6.60	25.00	37.40	17.00	19.80	14.60
WW	8.70	7.40	10.30	8.80	6.10	14.40	11.30	9.30	7.10	9.50	10.50	7.20	6.70	13.20	19.20	13.10	10.20	7.40
WH	10.40	7.70	14.70	10.40	7.40	19.10	14.60	11.00	8.70	15.90	16.20	7.70	5.30	17.00	21.70	15.20	11.50	8.10

Sample	SMF:NT	SMF:NT	SMF:NT	SMF:NT	SMF:NT	SMF:NT	SMF:NT	P82.11	P82.11	P82.11	P82.11	P82.11	P82.7	14:22	3122	14:22	14:22	2095
Code	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	GEA	GEB	GED	GEF	GEF
Mus & meas	513	613	713	813	913	113	213	117	217	317	417	517	117	100	110	100	100	118
D	19.90	15.10	11.20	8.40	6.30	4.91	3.40	54.30	36.90	26.80	14.20	7.85	44.80	38.70	17.20	41.50	35.00	29.90
U	10.90	8.50	6.36	4.70	3.70	2.36	1.64	26.70	18.90	14.00	7.70	4.16	21.20	14.00	6.20	13.70	12.00	9.10
WW	5.40	3.70	2.90	2.14	1.50	1.44	1.04	14.00	10.30	7.10	3.83	2.04	13.00	11.50	0.00	11.50	10.60	10.00
WH	5.40	3.90	2.72	1.84	1.60	1.31	1.12	16.40	9.20	7.80	3.60	2.11	14.60	12.00	6.30	15.60	12.00	12.90

Sample	2095	08:618	2063	2063	2061	14:81	4511.1	4511.1	2066	320303	320303	H10414	H10414	H10414	H10414	81824	VII545	92
Code	GEF	GEG	GEG	GEG	GEG	GEK	GEK	GEK	GE	CMS	CMS	CMS	CMS	CMS	CMS	CMS	CMT	CMT
Mus & meas	218	100	118	218	118	100	116	216	118	100	200	114	214	314	414	101	102	104
D	23.70	28.50	42.70	32.00	29.70	25.00	24.70	18.20	31.00	50.00	38.00	40.20	35.80	25.60	18.80	33.60	49.60	55.80
U	7.80	8.90	0.00	0.00	10.50	8.30	8.90	6.70	12.20	16.00	11.00	13.90	13.50	9.80	7.10	12.30	12.30	15.20
WW	8.00	8.50	13.00	10.40	10.50	7.50	7.70	6.10	0.00	9.00	0.00	10.00	7.90	6.30	4.40	0.00	14.70	16.00
WH	9.80	12.00	15.40	11.10	10.40	9.30	8.80	6.90	11.80	18.00	17.00	14.90	13.70	9.10	6.70	13.20	21.10	24.80

Sample	MFN	MFN:LT	MFN	MFN	H10415	H10415	H10415	H10415	H10415	H10415	H10415	MFN:LT	MFN	A373	A373	A371	MFN:HT	29:91
Code	CMT	CMC	CMC	CMC	CMC	CMC	CMC	CMC	CMC	CMC	CMC	CME	CME	CME	CME	CME	CMI	CMI
Mus & meas	112	112	112	212	114	214	314	414	514	614	714	112	112	105	205	105	112	100
D	50.00	26.00	22.40	16.50	39.60	28.30	20.50	14.00	9.60	6.74	4.95	32.00	37.90	41.80	28.20	80.00	21.00	25.50
U	15.00	9.40	5.80	6.80	13.80	10.20	7.20	5.30	3.92	2.81	0.00	11.00	11.00	12.90	8.20	22.00	7.00	5.00
WW	0.00	9.50	4.20	3.80	9.40	7.30	5.50	3.85	2.48	1.88	1.32	0.00	0.00	0.00	0.00	0.00	7.00	9.80
WH	21.50	11.40	9.10	7.00	14.70	10.50	8.00	5.36	3.51	2.29	1.61	11.00	11.00	16.80	11.80	34.00	8.70	12.20

Sample	20xx	92:20	MFN	2084	MFN	UEN	MFN	MFN	H10406	H10406	H10406	H7534	H7534	P82.5	P82.5	P82.5	P82.5	P82.5
Code	CMI	CMB	CMB	CMB	CMP	CMP	CMP	CMP	CMA	CMA	CMA	CMG	CMG	CMG	CMG	CMG	CMG	CMG
Mus & meas	119	100	112	118	112	104	112	212	114	214	314	114	214	108	208	308	408	508
D	41.20	45.00	24.80	47.20	35.70	32.30	42.00	35.00	43.00	28.80	19.70	36.00	23.40	13.90	8.95	5.82	3.74	2.54
U	7.10	0.00	6.50	10.80	8.40	5.30	16.20	12.80	10.30	7.67	5.82	8.40	7.80	3.88	2.81	2.05	1.56	1.15
WW	15.50	11.00	6.90	0.00	12.00	10.40	11.80	9.40	12.60	8.70	5.20	11.40	6.60	3.71	2.50	1.76	1.25	0.87
WH	20.00	16.00	0.00	21.90	16.00	15.70	19.40	13.50	19.10	13.60	8.20	15.40	9.20	6.18	3.81	2.36	1.41	0.85

Sample	P82.5	P82.5	P82.5	62-3	VII557	VII557	62-1	VII560	H10416	H10416	MFN	VII546	MFN	B9	H7530	A131/2	MFN	MFN
Code	CMG	CMG	CMG	CMG	CMD	CMD	CMW	CMF	CMF	CMF	CMF	CMO	CMO	CMN	CMN	CMN	CMN	CMN
Mus & meas	608	708	808	106	102	202	106	102	114	214	112	102	112	104	114	105	112	212
D	1.88	1.37	0.94	17.40	37.70	27.00	22.10	38.40	26.00	18.80	22.00	51.20	49.80	39.20	53.40	66.00	43.00	36.70
U	0.85	0.57	0.40	4.80	11.50	9.80	7.60	10.20	9.50	7.00	7.90	14.00	14.00	12.00	14.50	20.70	10.00	5.20
WW	0.64	0.49	0.40	5.20	10.20	9.10	5.40	9.80	7.30	5.90	5.30	15.00	13.20	14.10	15.40	0.00	14.00	7.90
WH	0.53	0.45	0.32	7.70	17.00	11.10	7.80	17.40	10.10	7.40	7.90	22.20	21.00	17.50	23.70	26.00	19.70	11.20

Section 2

Sample	62795	81823	81849	C34761	C82327	C82328	C83292	H10362	H10365	H10365	H10365	H10365	H10365	H10365	H10366	H10366
Code	LL	LL	LL	LL	LL	LL	LL	LL	LL2	LL2	LL2	LL2	LL2	LL2	LL1	LL1
Mus & meas	101	101	101	101	101	101	101	114	114	214	314	414	514	614	114	214
D	37.00	24.80	60.00	48.50	51.50	44.40	12.20	105.00	43.00	n.m.	n.m.	n.m.	n.m.	n.m.	82.50	64.60
U	17.00	13.10	31.00	26.00	26.00	21.50	8.20	52.00	22.10	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	33.20
WW	0.00	0.00	17.00	n.m.	n.m.	11.10	n.m.	21.00	11.70	9.00	6.60	5.30	3.90	3.10	16.90	14.10
WH	11.00	7.50	18.00	n.m.	14.40	12.50	3.30	33.00	12.20	9.00	6.90	4.60	3.50	2.20	22.70	17.60
R	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	25.40	19.10	13.70	10.10	7.90	6.10	47.30	36.50

Sample	H10366	H10366	H10366	H10366	H10366	H10366	H10366	H10367	H10368	H10368	H10370	H10398	VII601	VII601	VII603	VII605
Code	LL1	LL1	LL1	LL1	LL1	LL1	LL1	LL	LL3	LL3	LL	LL	LL4	LL4	LL	LL
Mus & meas	314	414	514	614	714	814	914	114	114	214	114	114	102	202	102	102
D	60.00	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	28.60	46.00	33.70	51.90	57.70	45.30	34.00	n.m.	120.00
U	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	15.10	23.20	17.40	26.00	28.70	24.00	17.70	n.m.	64.20
WW	13.80	10.00	8.20	6.10	4.70	3.85	2.50	6.90	12.70	8.70	n.m.	n.m.	10.20	9.10	15.70	21.00
WH	17.10	12.40	9.80	7.30	5.50	4.60	2.80	9.80	13.90	9.70	15.00	16.00	12.70	9.60	19.00	32.50
R	34.70	27.00	18.20	14.80	10.90	9.40	5.50	n.m.	26.60	n.m.	n.m.	n.m.	26.30	n.m.	n.m.	67.20

Sample	VII605	PROV36	PROV41	PROV41	P82.22	320101	320101	29:117	29:118	29:118	29:118	29:118	H10364	H10364	H10364	H10364
Code	LL	LL	LL	LL	LL	LL	LL	LL	LL	LL	LL	LL	LI	LI	LI	LI
Mus & meas	202	102	102	202	100	100	200	100	100	200	300	400	114	214	314	414
D	101.50	n.m.	65.50	52.50	185.00	150.00	110.00	160.00	38.00	53.00	53.00	21.00	56.00	46.30	36.30	29.60
U	55.50	n.m.	33.30	26.80	100.00	78.00	55.00	84.00	18.50	25.00	25.00	10.50	28.50	23.00	19.20	14.60
WW	19.00	14.30	15.40	13.20	26.00	33.00	25.00	26.00	10.50	14.50	16.00	5.30	n.m.	10.20	8.40	5.40
WH	27.50	18.30	19.60	16.10	46.00	40.00	31.00	44.00	11.40	16.00	17.00	5.80	16.70	12.80	10.30	7.20
R	60.00	n.m.	38.10	31.20	n.m.	87.00	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	32.40	26.30	21.10	15.40

Sample	H10364	H10364	231804	231804	C83292	81828	H7537	H7538	H7539	MfN	29:118	29:118	MfN	29:119
Code	LI	LI	LS	LS	LS	LS	LS	LS	LS	LS	LS	LS	LN	LC
Mus & meas	514	614	100	200	101	101	114	114	114	100	100	200	112	100
D	20.40	15.50	47.00	37.00	18.10	12.00	9.70	17.50	11.00	19.00	38.00	53.00	17.00	21.00
U	11.30	8.70	28.00	24.00	11.90	8.00	6.50	12.00	6.20	9.80	22.60	30.00	8.10	8.00
WW	4.70	3.60	n.m.	n.m.	n.m.	n.m.	2.16	n.m.	2.00	5.50	8.00	13.00	n.m.	n.m.
WH	3.60	2.70	12.50	8.00	3.80	2.70	1.80	3.00	2.00	5.50	8.30	13.20	4.90	7.50
R	11.60	8.30	28.00	21.00	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.

Section 3

Sample	38:196	38:196	23:459	29:101	14:38	08:608	29:100	3128	29:63	23:458	3154	3154	3154	08:610
Code	AME	AME	ARI	BEU	BIC	BRE	CAL	CLA	COS	CRA	CMA	CMA	CMA	CYC
Mus & meas	100	200	100	100	100	100	100	110	100	100	110	210	310	100
D	32.00	n.m.	50.00	38.00	25.00	23.30	20.00	24.80	30.00	34.00	35.70	34.50	n.m.	21.50
U	20.00	n.m.	22.00	16.50	13.00	15.00	9.00	10.90	13.00	17.00	15.00	15.50	10.90	9.50
WW	14.00	12.00	10.00	10.50	7.00	9.00	7.50	5.30	9.00	10.50	15.50	15.10	12.30	7.20
WH	8.00	9.50	15.00	11.50	7.00	4.50	6.00	7.90	4.00	9.30	12.40	11.60	8.70	7.00
Ah	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.
Rib number	16.00	n.m.	40.00	n.m.	45.00	34.00	21.00	40.00	35.00	n.m.	40.00	n.m.	n.m.	50.00

Sample	23:450	14:36	14:37	75:47	75:47	56:71	14:44	14:44	14:45	14:45	VI1600	VI1600	52:403	38:198
Code	DEK	DES	DRE	EUR	EUR	GRO	INT	INT	MIR	MIR	MOD	MOD	PAT	POL
Mus & meas	100	100	100	100	200	100	100	200	100	200	102	200	100	100
D	18.00	28.00	32.00	14.50	10.80	15.00	64.00	29.00	57.00	36.50	58.00	58.00	20.00	16.00
U	7.50	13.00	15.00	5.40	4.40	9.00	25.00	13.40	25.00	17.60	23.40	23.40	9.50	8.50
WW	6.00	9.20	9.10	7.70	5.00	3.50	15.20	8.60	16.00	9.50	12.80	12.80	5.00	8.00
WH	6.50	8.90	10.00	5.50	4.30	4.20	23.00	10.00	9.20	11.70	21.40	21.40	7.00	4.00
Ah	n.m.	n.m.	n.m.	n.m.	n.m.	4.00	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.
Rib number	15.00	35.00	40.00	n.m.	n.m.	12.00	40.00	n.m.	n.m.	n.m.	16.00	32.00	n.m.	38.00

Sample	8:607	3127	10:181	10:181	14:45	56:74	23:451	10:180	14:34	140215	14:46	14:46	14:46	08:620
Code	POM	PRO	PSE	PSE	QUE	QUI	RAR	REC	RIC	ROT	RUE	RUE	SAN	SAN
Mus & meas	100	110	100	200	100	100	110	100	100	100	100	200	100	100
D	47.50	31.00	67.00	47.00	57.00	36.50	23.00	43.50	60.00	42.00	76.20	55.90	27.30	37.30
U	25.50	14.00	28.00	18.00	25.00	17.60	n.m.	15.40	27.70	20.80	32.40	21.50	11.50	19.60
WW	15.00	3.50	n.m.	11.80	16.00	9.50	n.m.	12.30	17.70	12.50	23.00	16.70	7.50	6.00
WH	13.00	11.00	23.00	16.00	19.20	11.70	n.m.	14.10	20.00	13.30	21.00	20.00	8.50	10.80
Ah	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.
Rib number	42.00	n.m.	n.m.	n.m.	n.m.	n.m.	16.00	40.00	25.00	n.m.	n.m.	n.m.	n.m.	n.m.

Sample	29:71	56:74	60:27	60:25	60:25	29:100	29:70	WSB1	WSB1	WSB2	7177	14:38	3152	3153
Code	SCH	SCZ	SEI	SEP	SEP	SEW	STE	SUB	SUB	SUB	VAL	WAL	QCR	QQU
Mus & meas	100	100	100	100	200	100	100	120	220	120	107	100	110	110
D	41.00	15.00	28.00	54.00	21.00	27.00	36.00	56.30	43.90	59.20	39.20	37.20	32.00	39.00
U	13.00	7.50	14.00	27.00	11.50	12.50	15.00	26.00	20.10	n.m.	17.50	17.60	14.80	18.00
WW	11.00	5.00	8.00	15.00	7.00	9.00	7.20	n.m.	11.40	18.00	7.00	9.00	9.30	10.00
WH	21.40	5.00	8.50	15.00	5.00	8.00	12.50	19.00	14.20	22.00	13.50	11.00	9.00	12.20
Ah	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.
Rib number	n.m.	n.m.	40.00	32.00	n.m.	54.00	n.m.	n.m.	15.00	n.m.	80.00	29.00	n.m.	n.m.

The University of Hull

Some Famennian (Upper Devonian) ammonoids from north western Europe

being a Thesis submitted for the Degree of

Doctor of Philosophy

in the University of Hull

by

Jonathan David Price, B.Sc.(Hons.), London

December 1982

1

Volume 2

Chapter 5

Illustrations

Textfig. 5.1 Hexaclymeniinae

Progonioclymenia (Prog.) aegoceras (Frech 1902)

A, growth-line; B, suture at D=17.9, WW=ca5 and WH=3.7 from Mbg 3130, X10: figured by Schindewolf (1923a, pl. XVIII, fig. 12), from Braunau near Wildungen, Kellerwald; D, suture, after Schindewolf 1937a, fig. 6 (magnification and size unstated).

Hexaclymenia hexagona (Wedekind 1908)

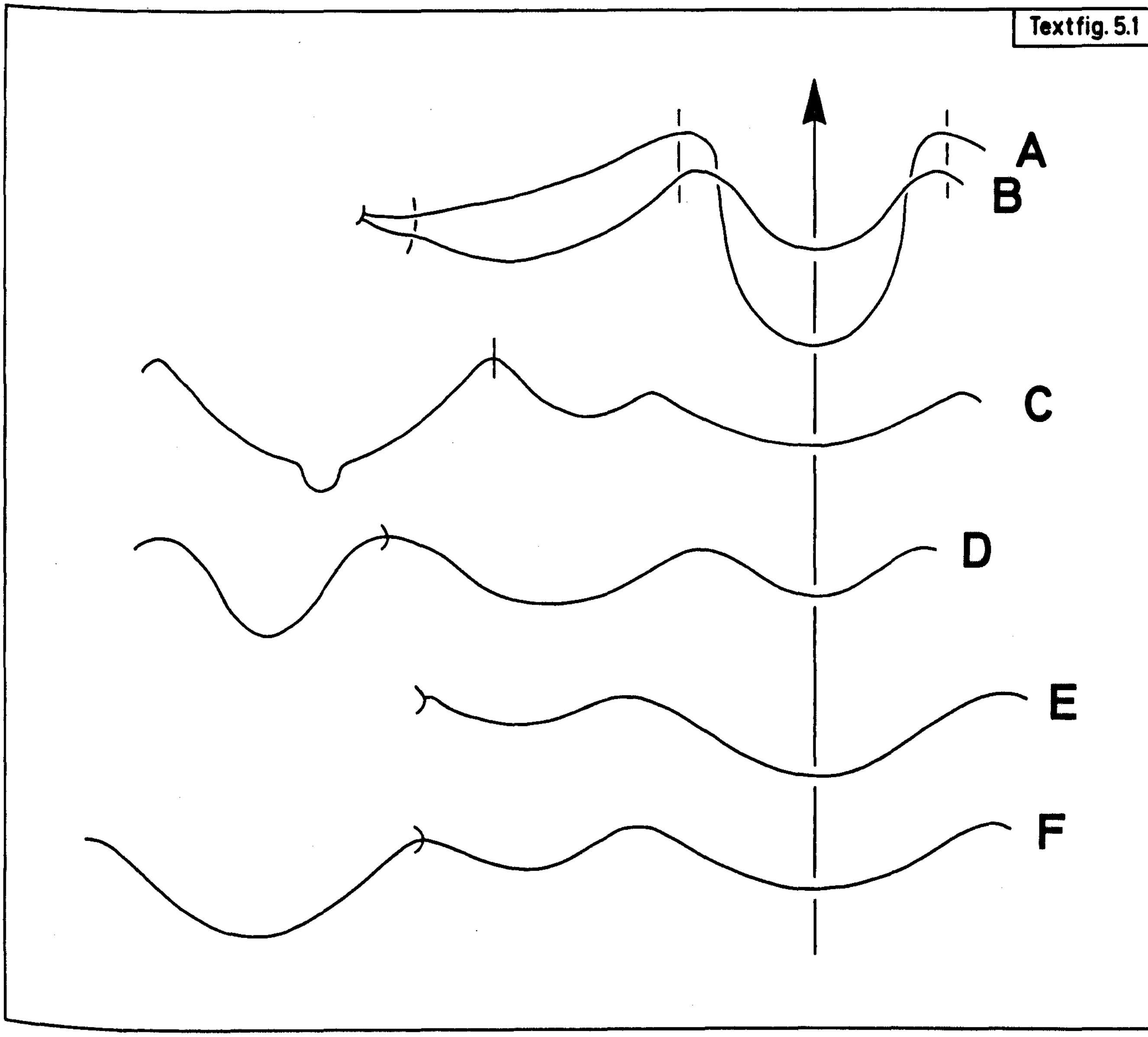
C, suture, after Schindewolf 1972, fig. 1a, (magnification and size unstated).

Progonioclymenia (Soliclymenia) paradoxa (Münster 1842)

E, suture, after Schindewolf 1937a, fig. 8, (magnification and size unstated).

Progonioclymenia (Soliclymenia) solarioides (von Buch 1838)

F, suture, after Schindewolf 1937a, fig. 7, (magnification and size unstated).


Textfig. 5.1
A
B
C
D
E
F

Textfig. 5.2 Sellaclymenia

Sellaclymenia plana (Münster 1832)

A, whorl cross-section at D=75, X2; B, suture and growth-line (both reversed) at D=ca73, WW=ca14 and WH=28, X1.66: BSP AS VII 594, lectotype, Schübelhammer,Oberfranken; C, suture and growth-line (both reversed) at D=ca30, WH=11, X3.33: BSP AS VII 589, lectotype of Clymenia angulosa (Münster 1839), Schübelhammer, Oberfranken.

Sellaclymenia torleyi (Wedekind 1914)

D, suture and growth-line (both reversed) at D ca 41, WW=8.9, WH=14, X3.33: MfN c596, holotype of Sell. spinosa Schmidt 1924, pl. 7, fig. 8, from Dasberg, Sauerland; E, suture (reversed) at WH=8, X3.33: RE 551.734.5 A254, lectotype, from Hövel, Sauerland.

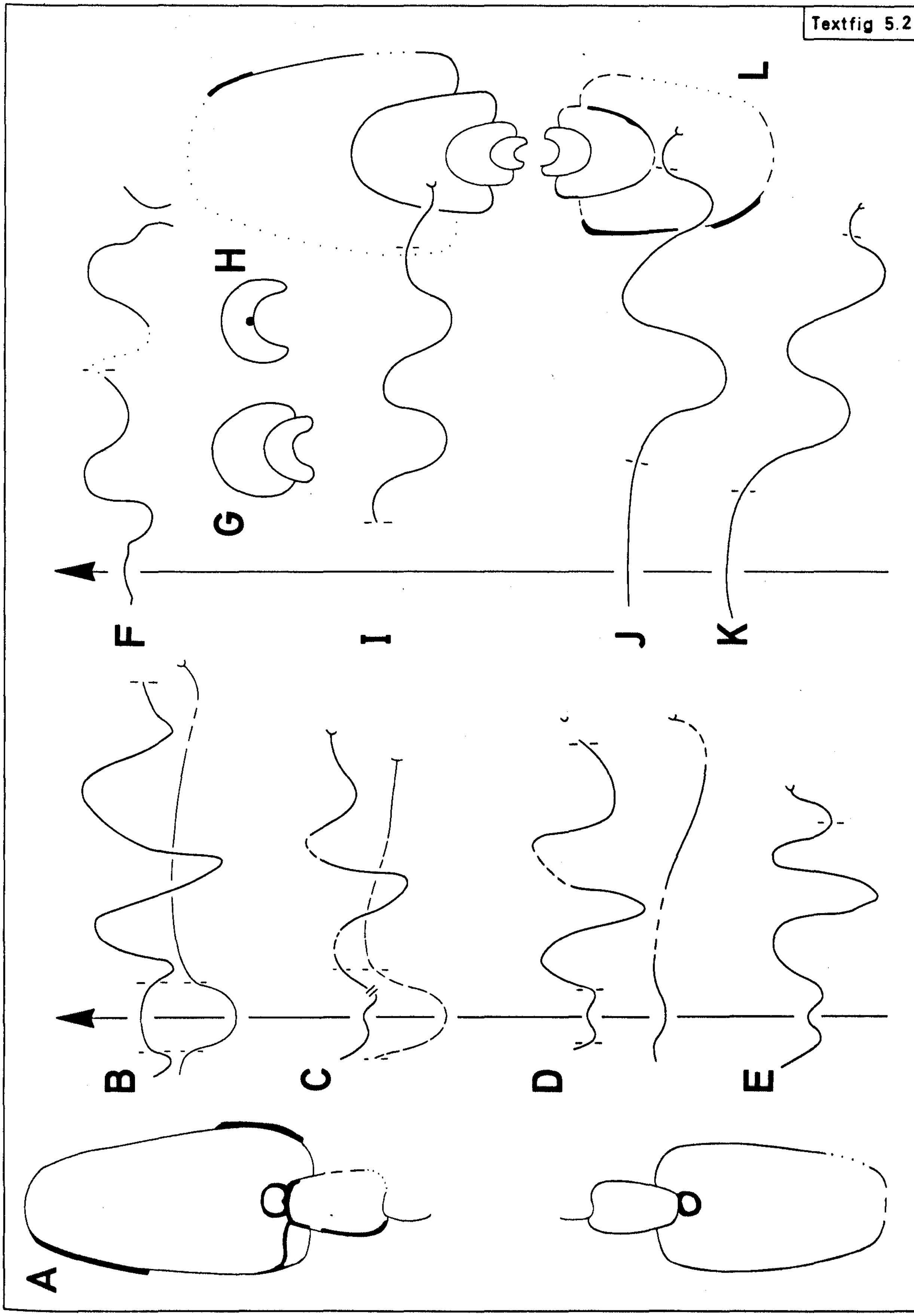
Biloclymeniinae

Biloclymenia cf. bilobata (Münster 1839)

F, suture at WW=4.4, WH=3.5, X3.5; H, whorl section, X3.5: BSP AS VII 525; G, whorl section at D=11, WW=5.5, WH=4.35, X3.5, BSP AS VII 524. Both specimens from Schübelhammer, Oberfranken.

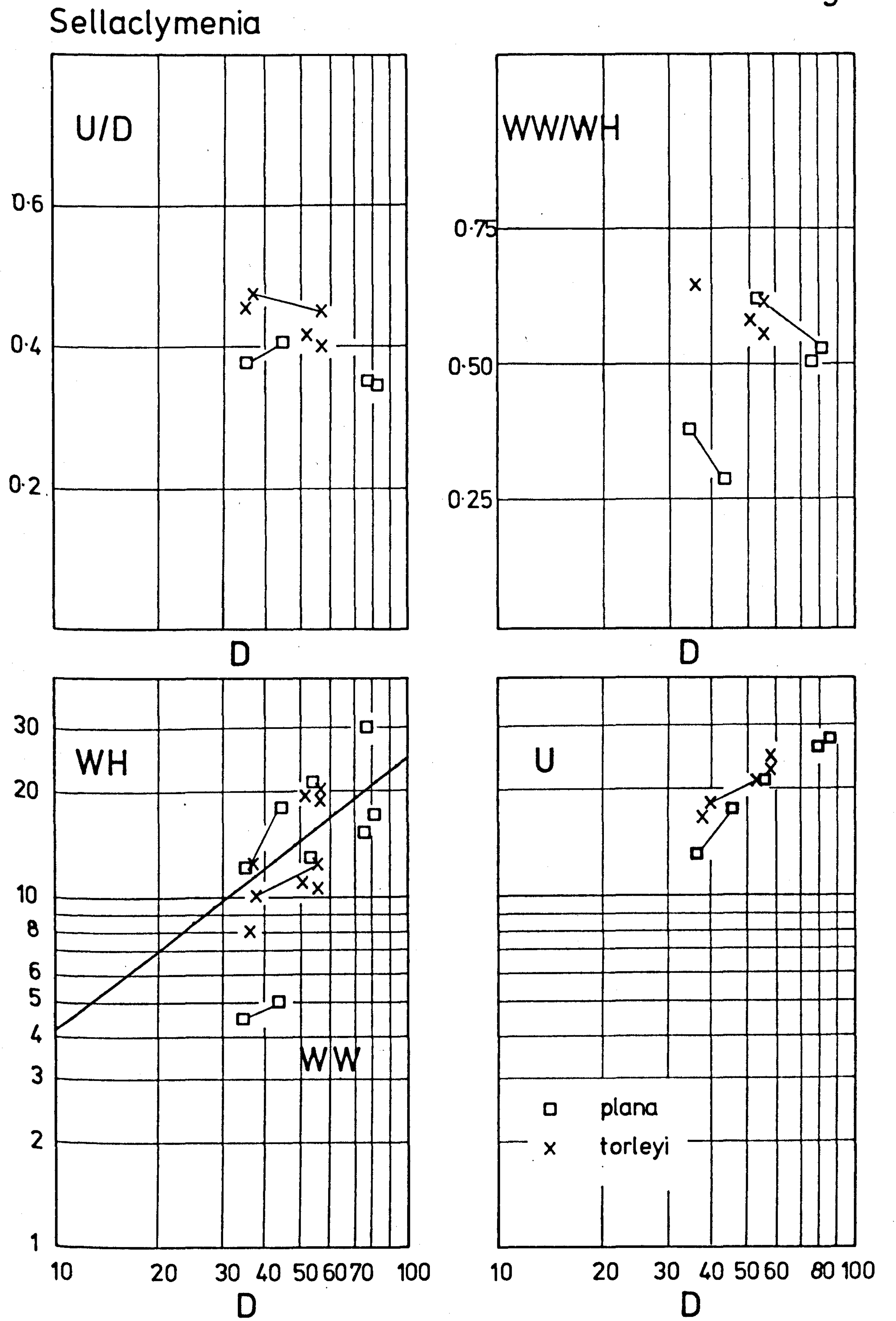
Biloclymenia sp. a

I, suture at D ca 30, X3.33: MfN, Beil, Sauerland. Specimen figured by Schindewolf (1937a, pl. 1, fig. 10) as Bilo. bilobata and here in Pl. 5.11, Figs. 3,4; J,K, sutures at WH=20.5 and 16.3 respectively, X3.33; L, cross-section at D=68, X1.5: KW 2091, Kasberg, Langenholthausen, Sauerland.



Textfig 5.2

Textfig. 5.3


Sellaclymenia
U/D
0·6
0·4
0·2
D
WW/WH
0·75
0·50
0·25
D
WH
30
20
10
8
6
5
4
3
2
1
WW
10
20
30
40
50
60
70
100
D
U
plana
torleyi
10
20
30
40
50
60
80
100
D

Textfig. 5.4 Endosiphonites

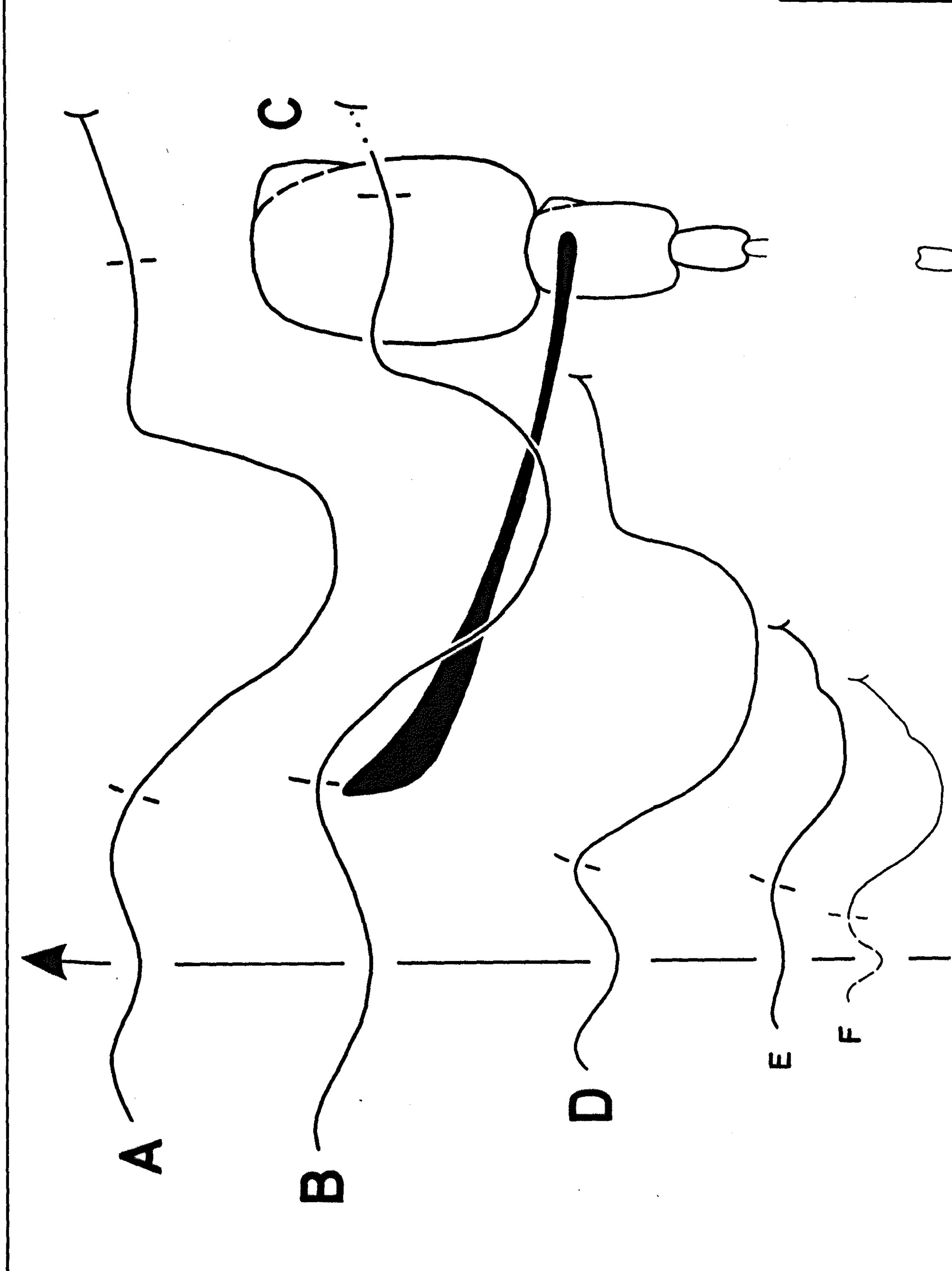
Endosiphonites (Costaclymenia) muensteri Ansted 1838

A, suture (reversed) at D=7.3, WW ca 11, WH=25.7, x4: SM H4010, Petherwin Beds, Petherwin, Cornwall.

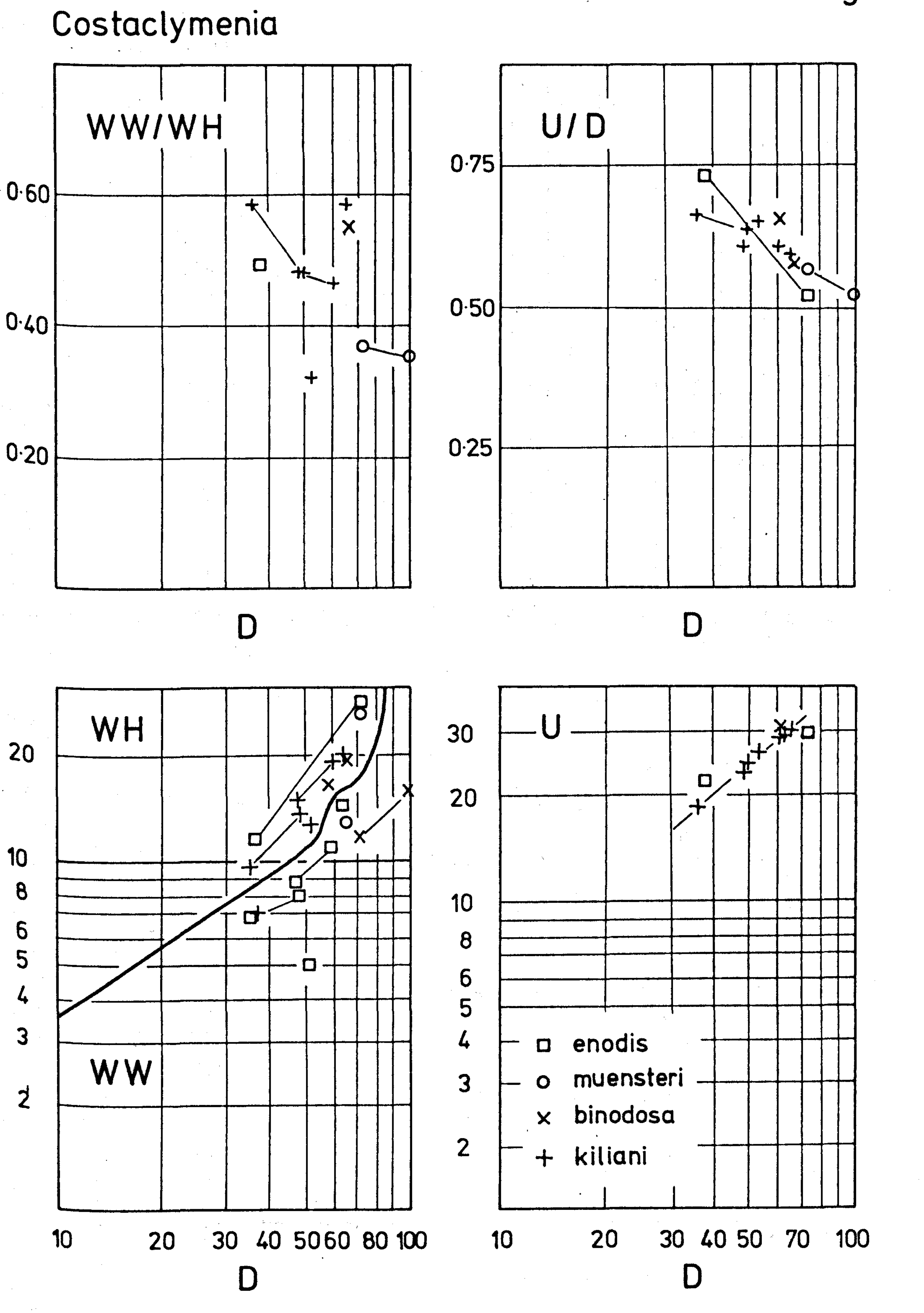
Endosiphonites (Costaclymenia) kiliani (Wedekind 1914)

B, suture and rib at WW=7.2, WH=12, x8: BSP AS VII 590, Schübelhammer, Oberfranken. Figured by Münster (1839, pl. XII, figs. 3a-c) as Cl. binodosa. C, whorl cross-section at R=35, WW=12, WH=17, x3; D-F, sutures at D ca 34, WH=8.8, x10; WH=4.65, WW=3.6, x10; WH=3.2, x15, respectively from SM H10385, Schübelhammer, Oberfranken.

Textfig. 5.4

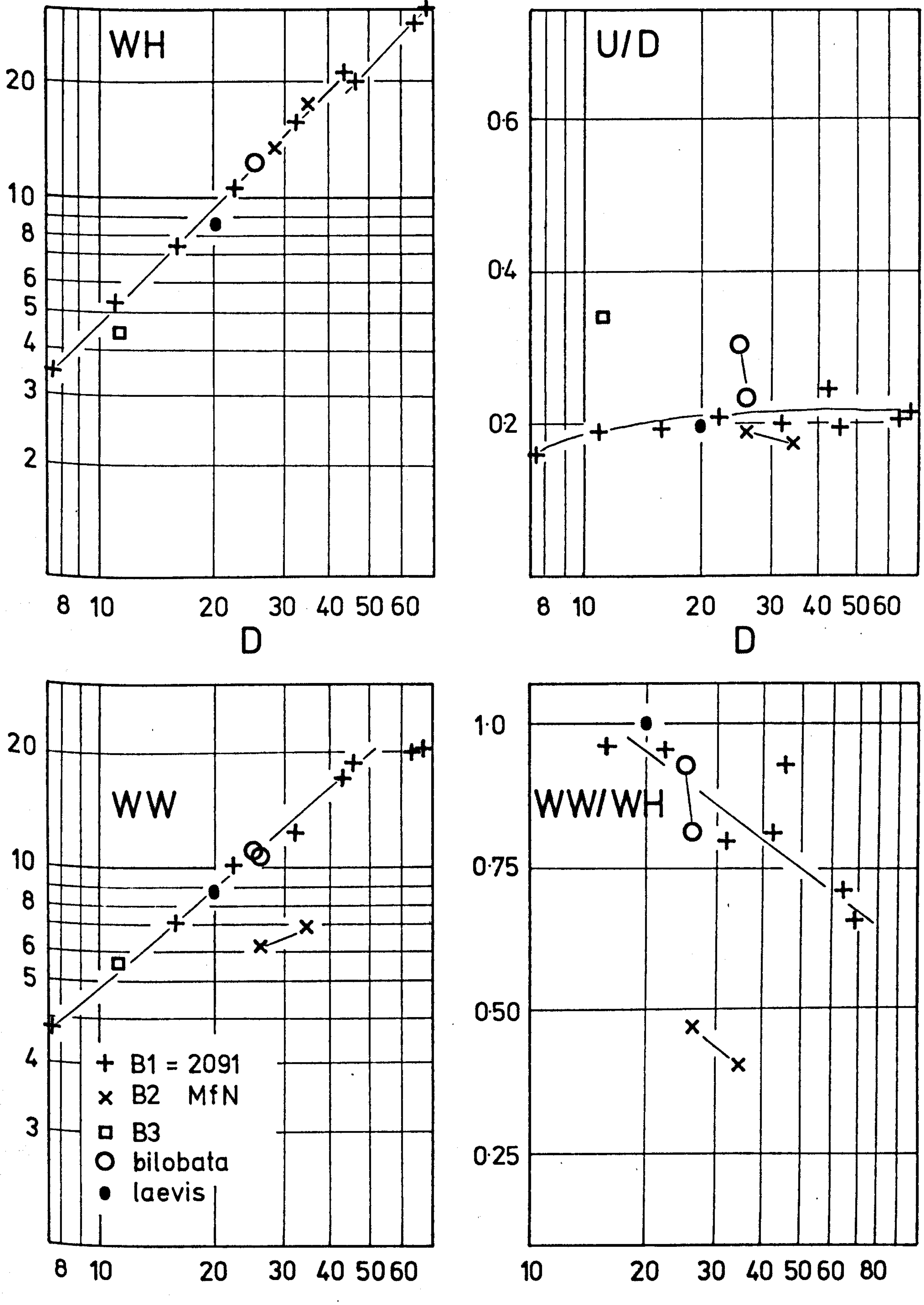


Textfig. 5.5


Costaclymenia
WW/WH
0·60
0·40
0·20
D
U/D
0·75
0·50
0·25
D
WH
WW
20
10
8
6
5
4
3
2
10 20 30 40 50 60 80 100
D
U
30
20
10
8
6
5
4
3
2
enodis
muensteri
binodosa
kiliani
10 20 30 40 50 70 100
D

Textfig. 5.6

Biloclymenia



Textfig. 5.7 Gonioclymenia and Sphenoclymenia

Gonioclymenia (Gonioclymenia) speciosa (Münster 1831)

A, suture at D=91, X2.66; B, suture at D ca 20, WH=6, X7: BSP AS VII 538, Münster Collection, Schübelhammer, Oberfranken.

Gonioclymenia (Gonioclymenia) subcarinata (Münster 1839)

C, suture at D=68, X3.33: BSP AS VII 596, Münster Collection, Schübelhammer, Oberfranken; D, suture (reversed, composite of adjacent sutures) at D ca 59, WW ca 15, WH ca 29: RE 551.734.5 A256, lectotype of Gon. praematura Wedekind, Torley Collection, Hövel, Sauerland.

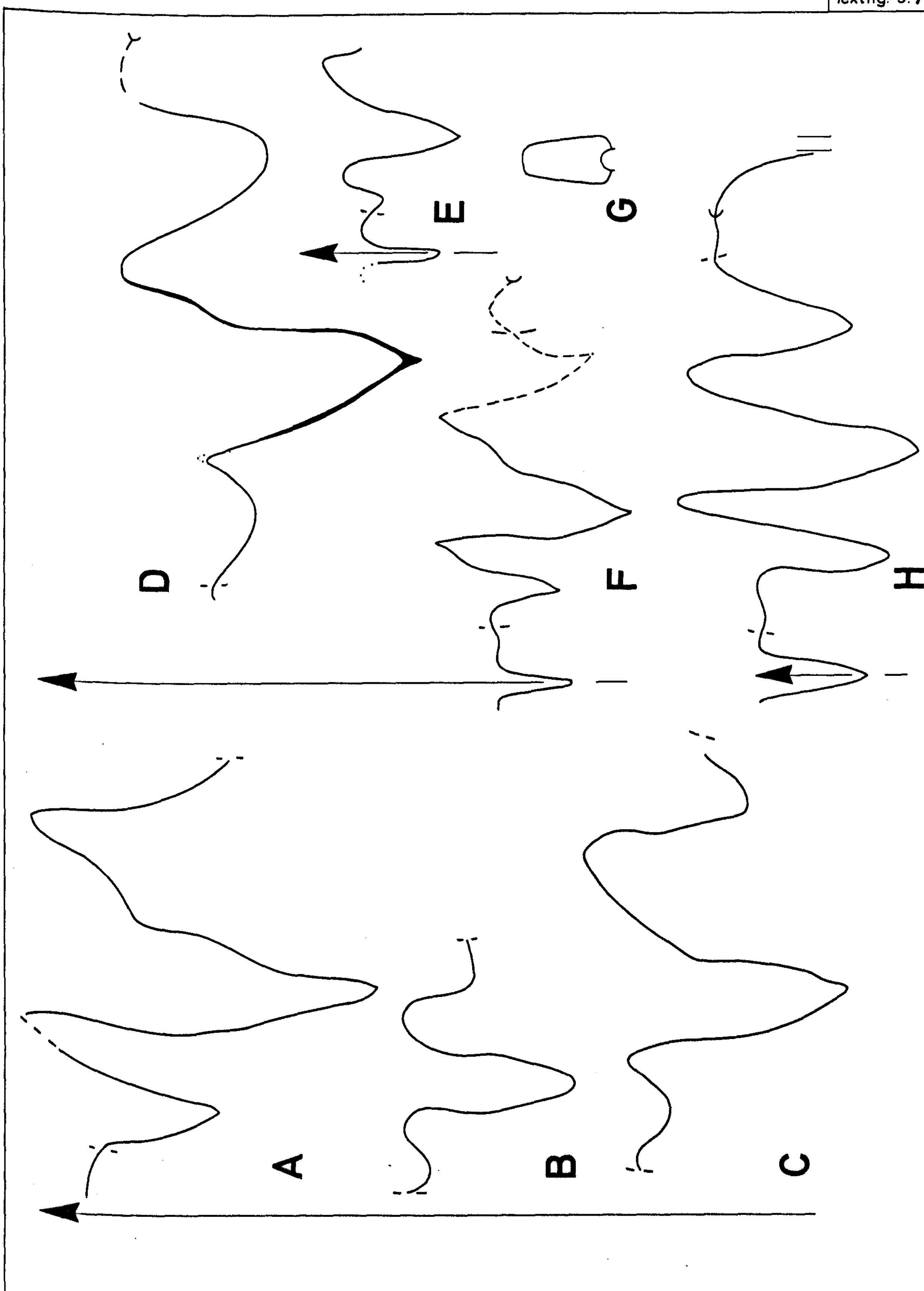
Gonioclymenia sp.

E, suture (reversed) at D ca 30, WW=5.5, WH=12: SM H10407, Münster Collection, Schübelhammer, Oberfranken.

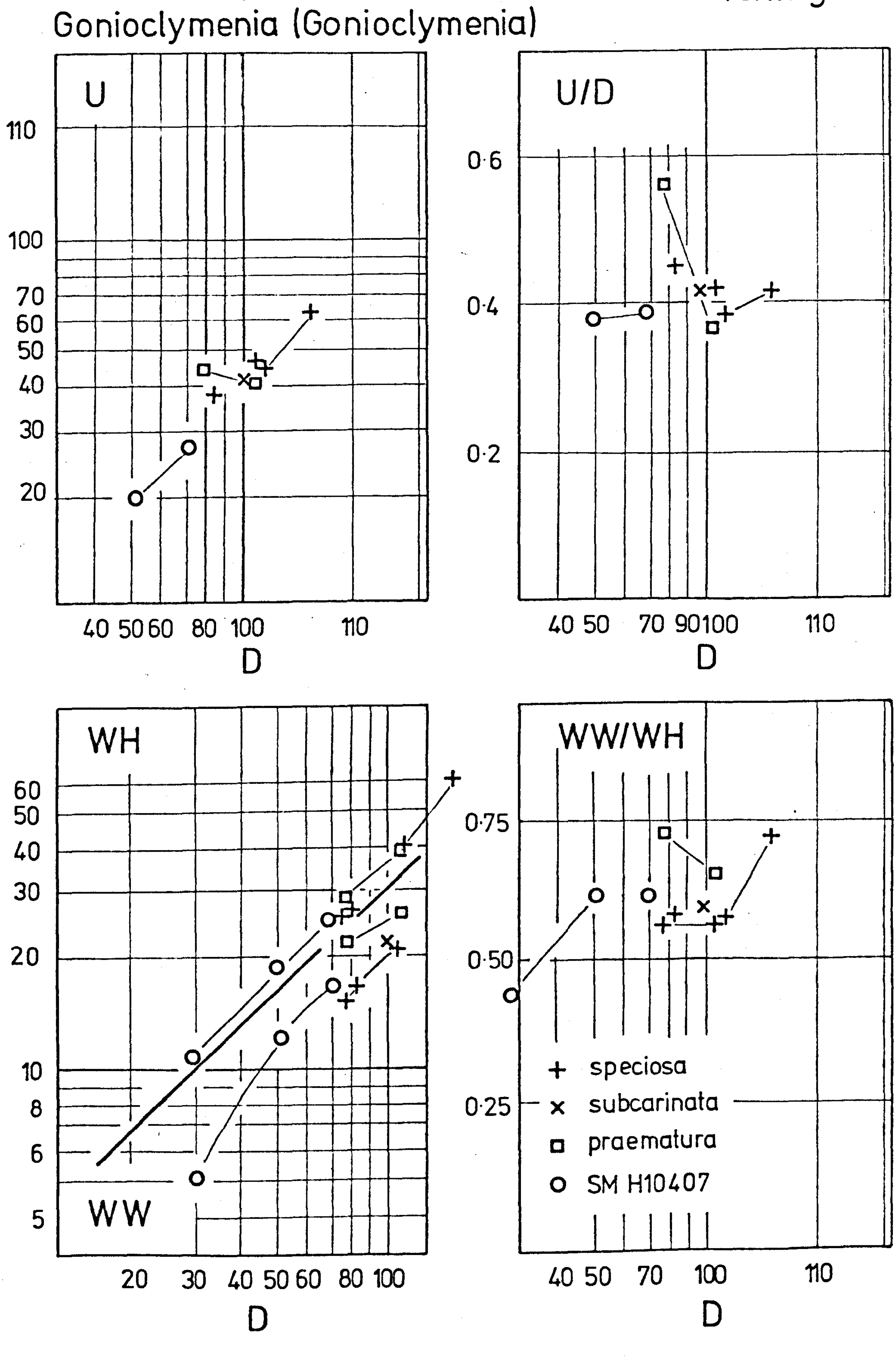
Sphenoclymenia intermedia (Münster 1839)

F, suture, X1.66; G, whorl section, X0.5, at WW=20.9, WH=40: BSP AS VII 586, lectotype, Münster Collection, Schübelhammer, Oberfranken.

Textfig. 5.7



Textfig. 5.8


Goniochymenia (Gonioclymenia)
U
110
100
70
60
50
40
30
20
40 50 60 80 100 110
D
U/D
0·6
0·4
0·2
40 50 70 90 100 110
D
WH
60
50
40
30
20
10
8
6
5
WW
20 30 40 50 60 80 100
D
WW/WH
0·75
0·50
0·25
40 50 70 100 110
D
speciosa
subcarinata
praematura
SM H10407

Textfig. 5.9 <u>Gonioclymenia</u>

<u>Gonioclymenia</u> (<u>Kalloclymenia</u>) <u>subarmata</u> (Münster 1832)

A, suture (reversed) at D=98, X3.33: BSP AS VII 537, lectotype; B, whorl section at D=100, X1.33: SM H10394, Münster Collection, Schübelhammer, Oberfranken.

<u>Gonioclymenia</u> (<u>Kalloclymenia</u>) <u>uhligi</u> (Frech 1902)

C, suture at D ca 45, WW=12.2, WH=15.3, X3.33: MfN c550 lectotype, Dzikowiec, Poland.

<u>Gonioclymenia</u> (<u>Kalloclymenia</u>) <u>insignis</u> (Phillips 1841)

D, suture at D=45, WH=13, X3.66: GSM 7083, holotype, Petherwin Beds, Cornwall.

<u>Gonioclymenia</u> (<u>Kalloclymenia</u>) <u>crassa</u> (Wedekind 1914)

E, suture (reversed) at D=52, and growth-line/tubercle at D=37, WW ca 10, WH=12.8, X3.33: RE 551.734.5 A255, lectotype, Torley Collection, Hövel, Sauerland.

<u>Gonioclymenia</u> (Gen. Nov. <u>B</u>) <u>frechi</u> Lange 1929

F, suture at D=59.2, WW=11.2, WH=15.1, X5: MfN, Dzikowiec, Poland.

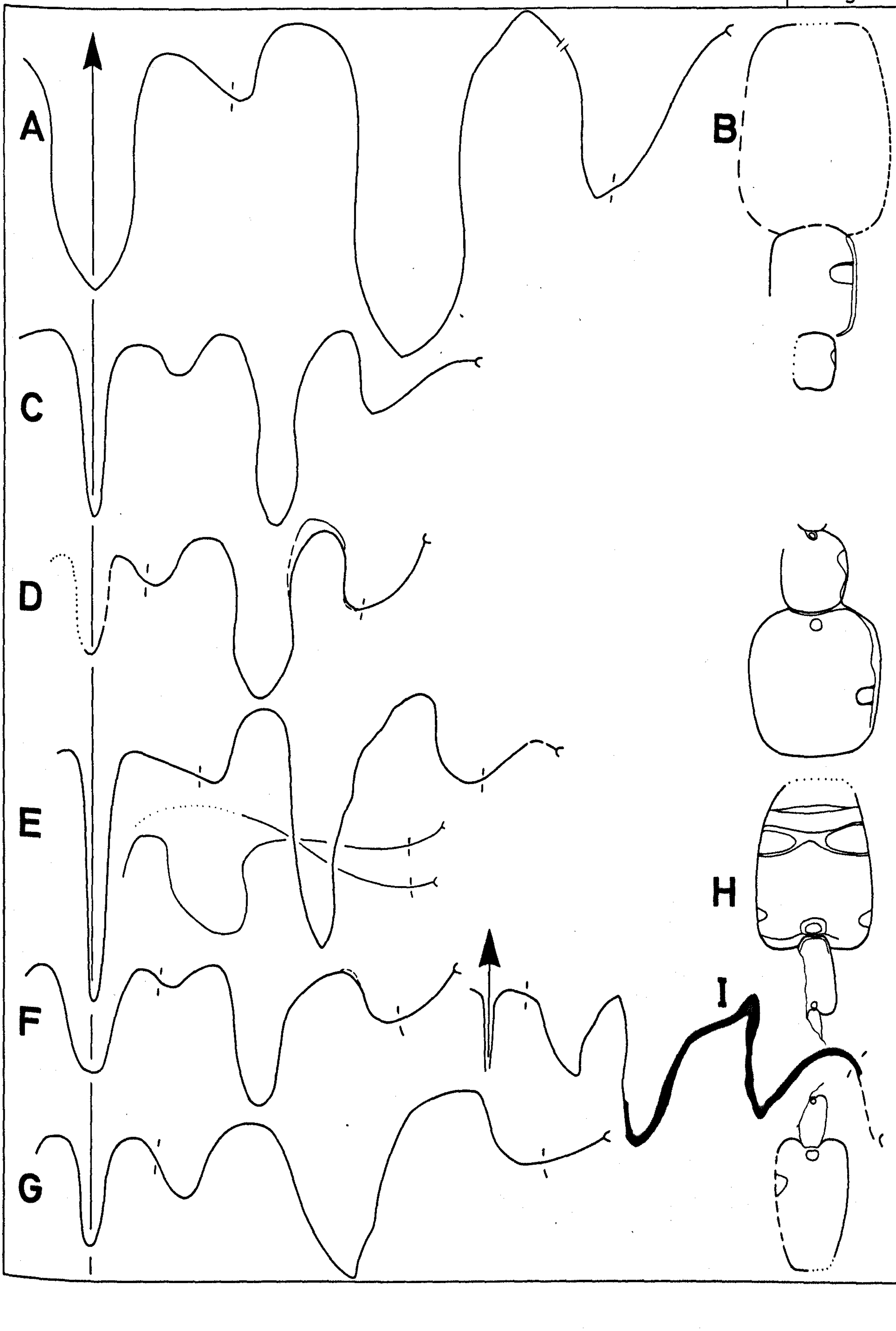
<u>Gonioclymenia</u> (Gen. Nov. <u>B</u>) <u>wocklumensis</u> Lange 1929

G, suture (reversed) at D ca 30, X6.66: MfN, holotype, Burg, Wocklum, Sauerland.

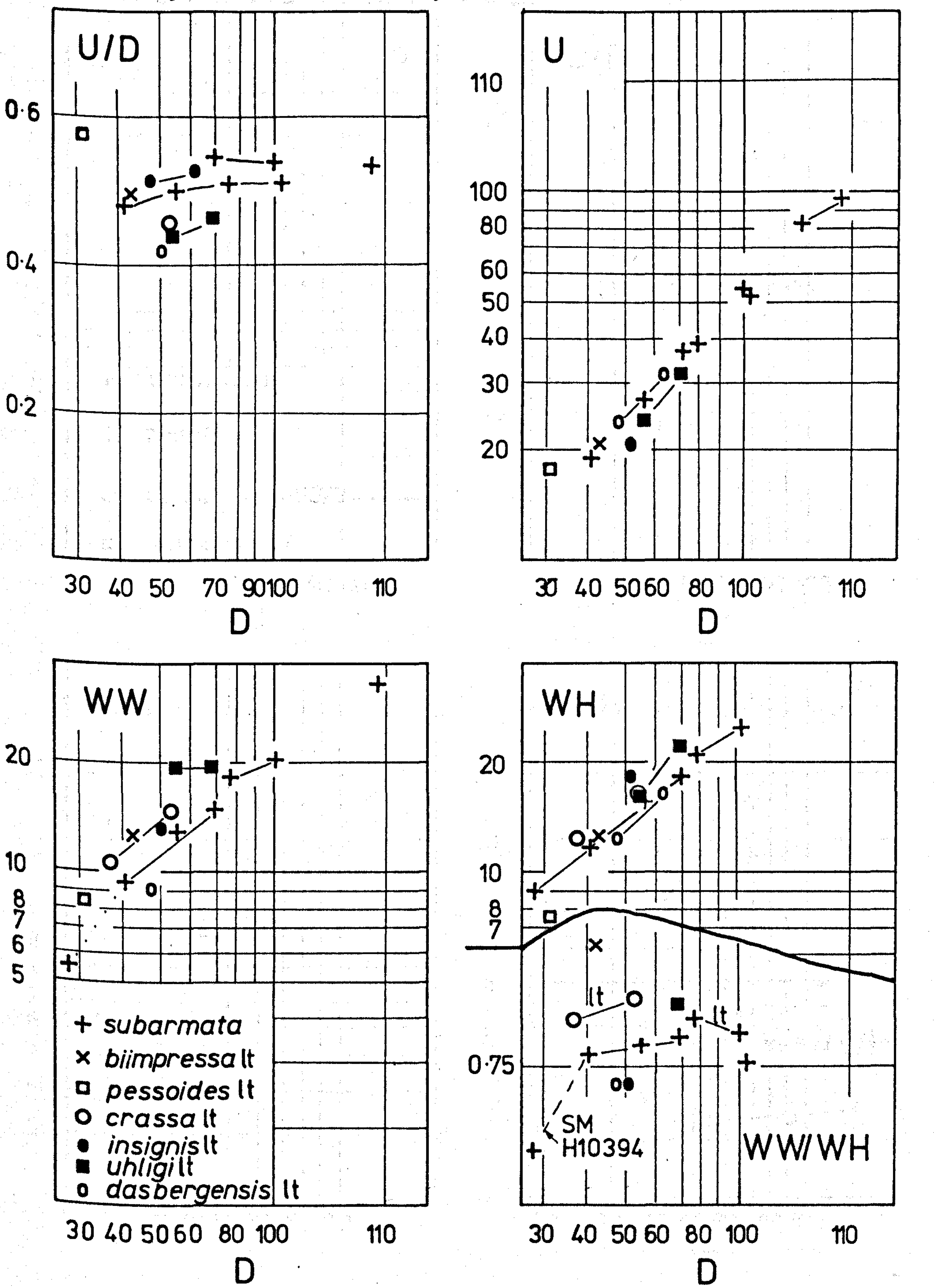
<u>Gonioclymenia</u> (Gen. Nov. <u>B</u>) aff. <u>wocklumensis</u> Lange 1929

H, suture (reversed) at D=88, WW=21, WH=36, X1.66, and I, cross-section at D=135, X0.66: SM H10373, Münster Collection, Schübelhammer, Oberfranken.

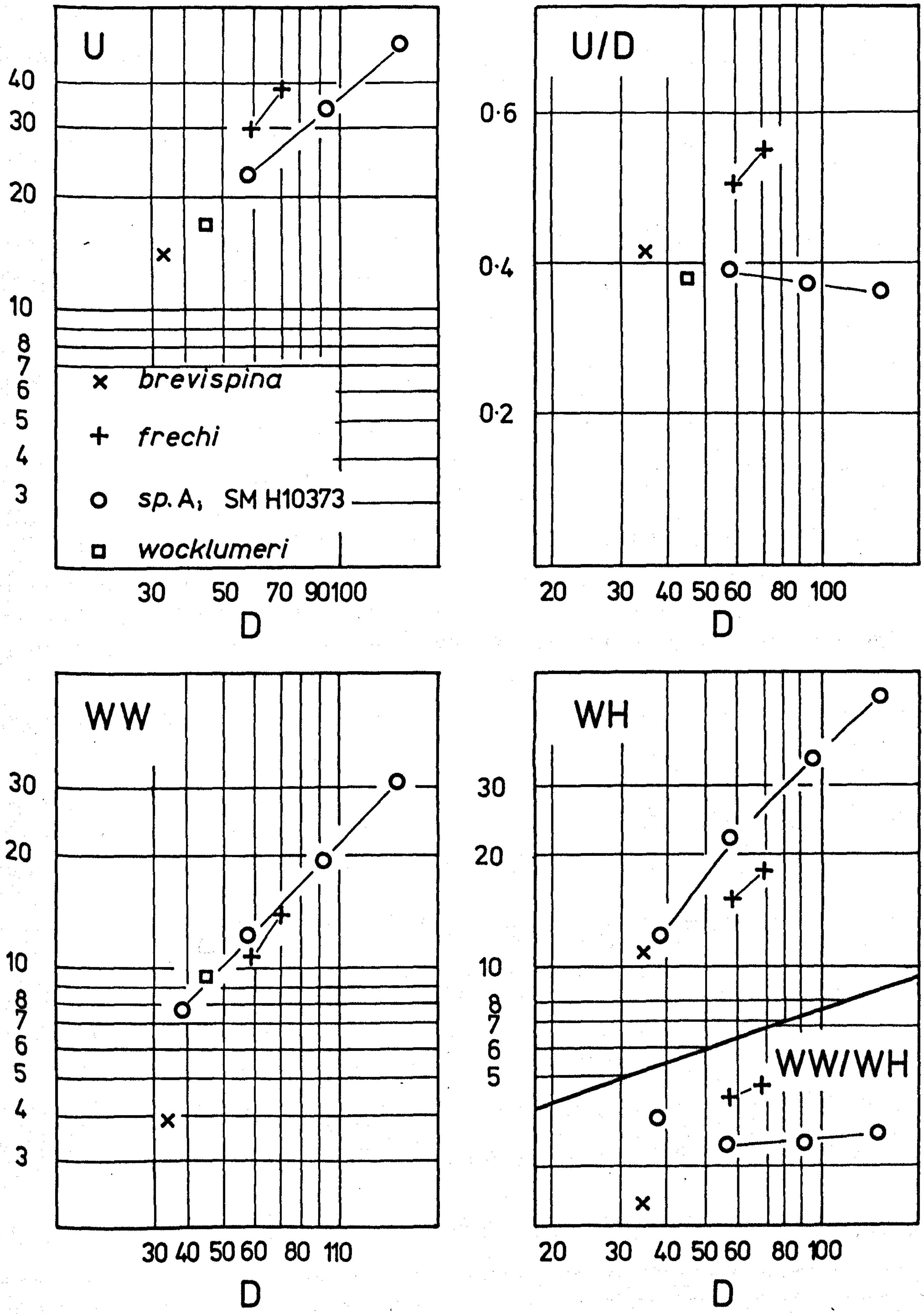
Textfig. 5.9



Goniocylmenia (Kalloclymenia)



Gonioclymenia (S. nov. A and B)



Textfig. 5.12 Platyclymeniidae

<u>Sulcoclymenia</u> <u>sulcata</u> (Schindewolf 1923a)

A, suture and growth-line at D=15, WW=2.5, WH=3.5, x8: Mbg 3129a, lectotype; B, suture at D=10, x20: Mbg 3129b; both Schindewolf Collection, Bed 10, Kirch-Gattendorf, Oberfranken. C, suture at WH=5.2 and growth-line at WH=7.4, both reversed, x6.66: KW 2065, Wäschholz, Oberfranken.

<u>Ornatoclymenia</u> <u>ornata</u> (Münster 1834)

D, growth-line at D ca 19, WW=5.5, WH=17.5, x10; E, whorl section at D=22.1, U=8.6, WW=6.2, WH=8.2, x3.66: SM H10382, Münster Collection, Schübelhammer, Oberfranken. F, suture at D=21, and growth-line at D=24, x6.66: BSP AS VII 550, lectotype, Münster Collection, Schübelhammer, Oberfranken.

<u>Platyclymenia</u> (<u>Pleuroclymenia</u>) <u>crassissima</u> Schindewolf 1955

G, rib and constrictions at WW=12.2, WH=8.3, suture (reversed) at WW=11.8, WH=8, x3.33; H, cross-section at D=30, x2.5: Mbg 3154, holotype, Kirschofen, Weilburg.

? <u>Stenoclymenia</u> <u>valida</u> (Phillips 1841)

I, suture at WW=7, WH=13.2, x3.66: GSM 7177, lectotype, Petherwin Beds, Petherwin, Cornwall. Figured by Phillips 1841 (pl. LIV, figs. 245a-b).

<u>Platyclymenia</u> (<u>Platyclymenia</u>) <u>quenstedti</u> (Wedekind 1914)

J, growth-line at D=28.3, WW=8.2, WH=8.9, x7.66: RE 551 734.5 A150/1, Torley Collection, Beil, Sauerland.

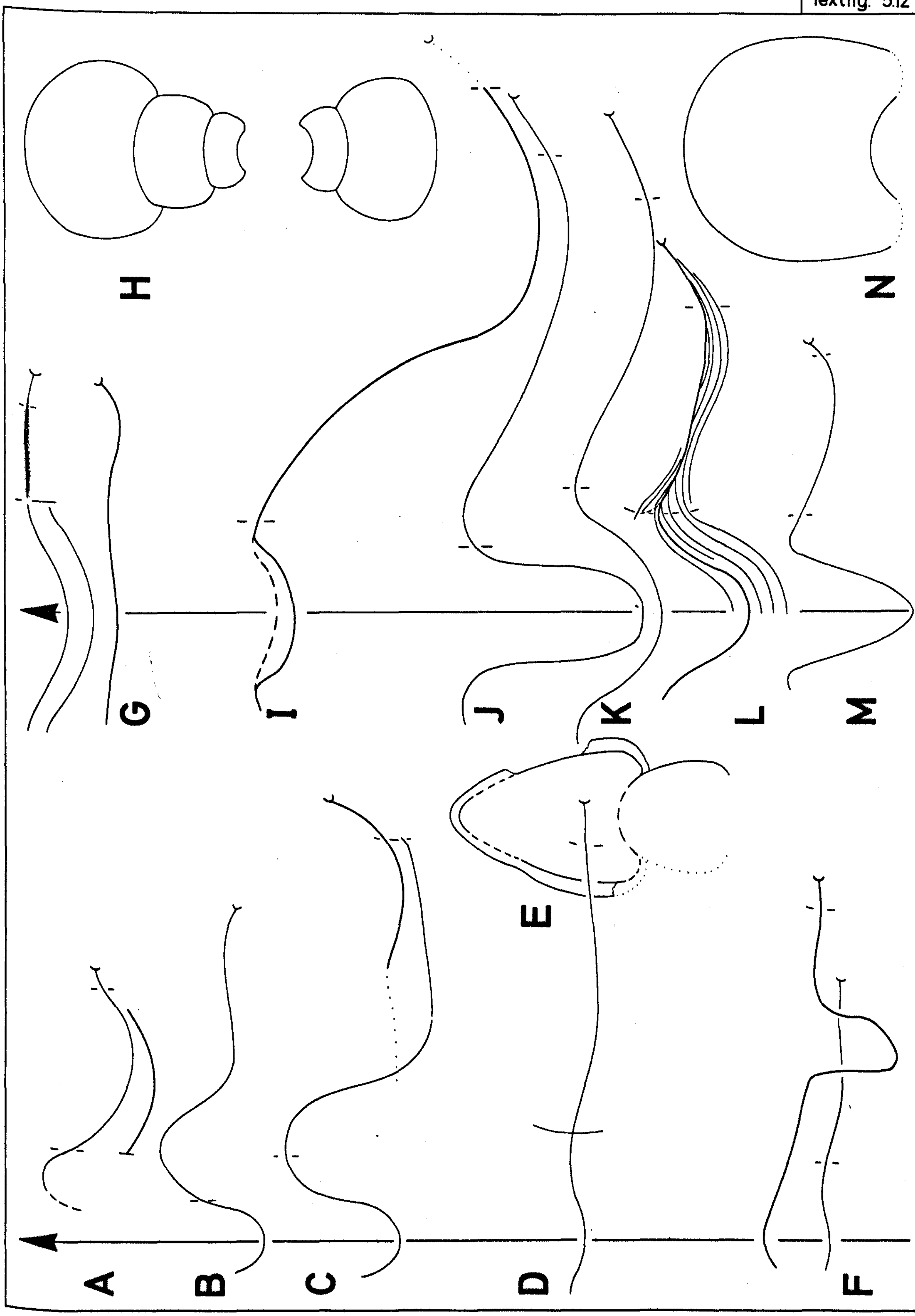
<u>Platyclymenia</u> <u>richteri</u> Wedekind 1914

K, growth-line at D=29.2 and L, rib course at WW=7.2, WH=5.8, x7.66: Mbg 3126, Langenaubach.

<u>Platyclymenia</u> <u>annulata</u> (Münster 1832)

M, growth-line and N, whorl section at D=22, x6.66: Mbg 3125, Schindewolf Collection, Bed 14, Kirch-Gattendorf, Oberfranken.

Textfig. 5.12

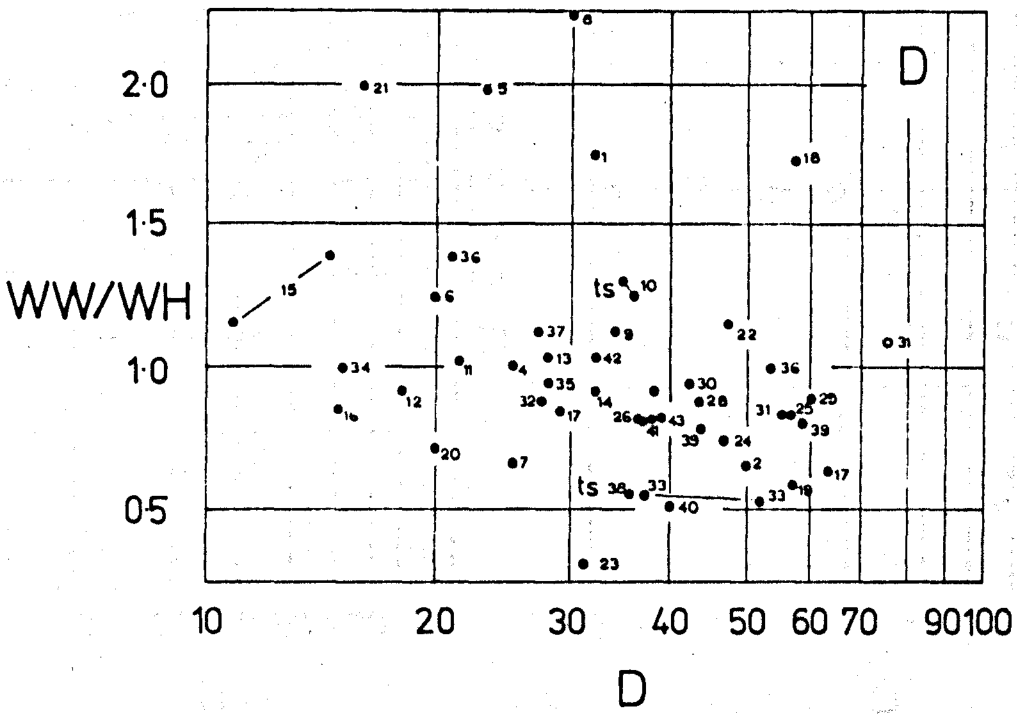


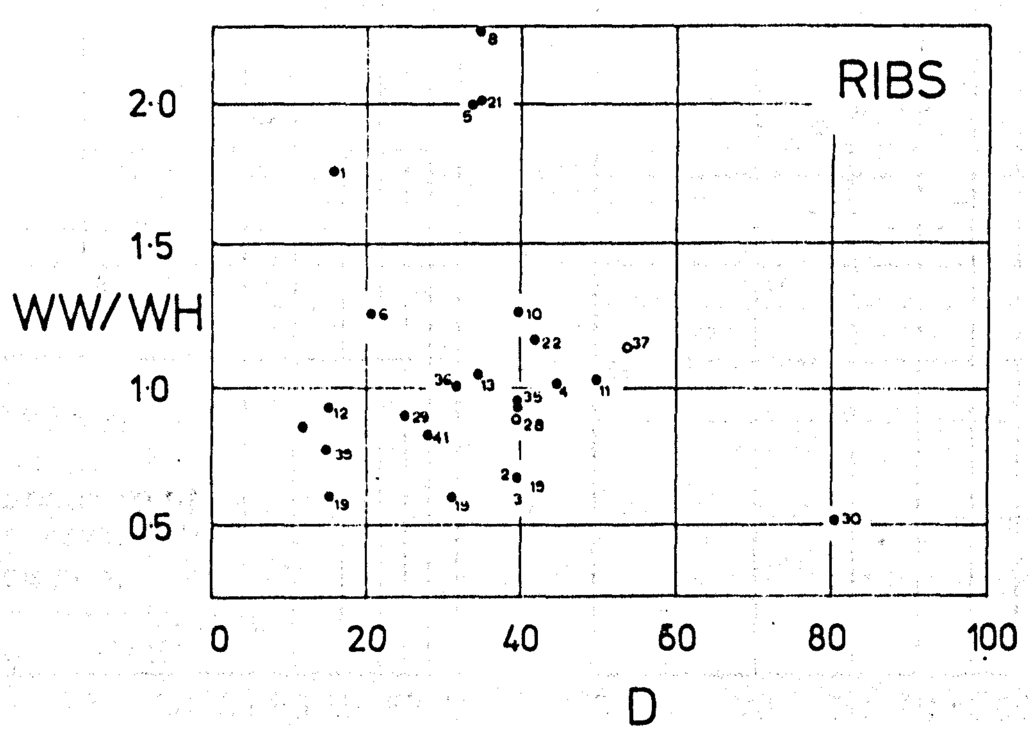
Key to Textfig. 5.13

Data is taken from type specimens, where available.

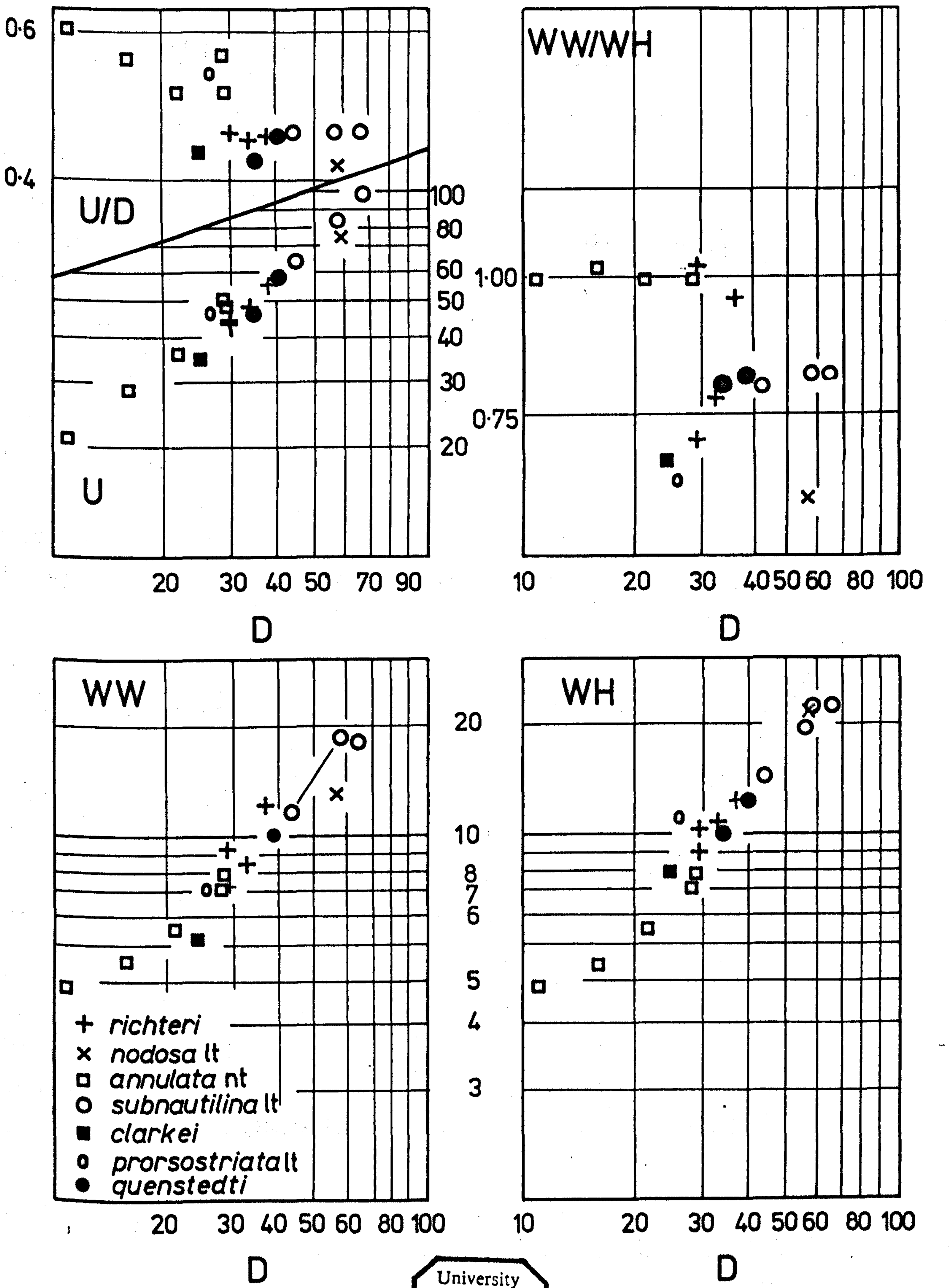
		Name		Data Code	
1		Pleur.	americana	AME	
2		Plat.	arieticosta	ARI	
3		Plat.	beuelensis	BEU	
4		Plat.	bicostata	BIC	
5		Pleur.	brevicosta	BRE	
6	?	Pleur.	callimorpha	CAL	
7		Plat.	clarkei	CLA	
8		Pleur.	costata	COS	
9		Plat.	crassa	CRA	
10		Pleur.	crassissima	CMA	
11		Plat.	cycloptera	CYC	
12		Plat.	denckmanni	DEK	
13		Plat.	densicosta	DEN	
14		Plat.	valida sensu Drevermann 1901	DRE	
15	?	Pleur.	eurylobica	EUR	
16		Plat.	grossi	GRO	
17		Plat.	intracostata	INT	
18	?	Plat.	mirabilis	MIR	
19		Plat.	nodosa	NOD	
20		Plat.	pattisoni	PAT	
21		Pleur.	polypleura	POL	
22	?	Plat.	pompeckii	POM	
23	?	Plat.	prorsostriata	PRO	
24		Plat.	pseudoflexuosa	PSE	
25		Plat.	quenstedti	QUE	
26		Plat.	quiringi	QUI	
27		Plat.	raricosta	RAR	
28		Plat.	recticosta	REC	
29		Plat.	richteri	RIC	
30		Plat.	rotundata	ROT	
31		Plat.	ruedemanni	RUE	
32		Sten.	sandbergeri	SAN	
33		Sten.	schindewolfi	SCH	
34		Plat.	schleizi	SCZ	
35		Plat.	semiornata	SEI	
36		Plat.	semperornata	SEP	
37		Plat.	senilis	SEN	
38		Sten.	stenomphala	STE	
39		Plat.	subnautilina	SUB	
40		Sten.	valida	VAL	
41		Plat.	walcotti	WAL	
42		Plat.	quenstedti crassa	QCR	Mbg 3152
43		Plat.	quenstedti quenstedti	QQU	Mbg 3153

Platyclymenia Textfig. 5.13

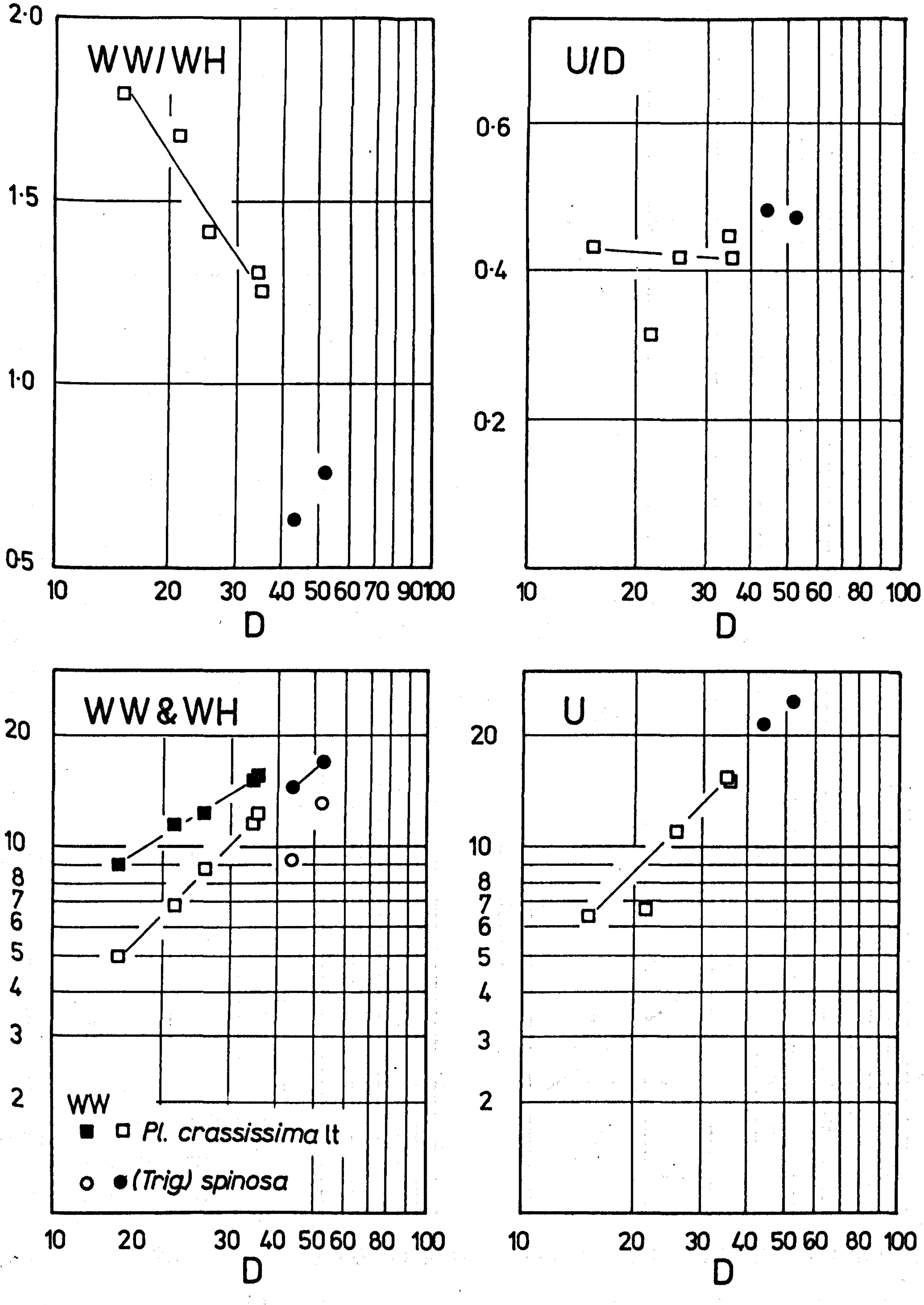




Platyclymenia (Platyclymenia)

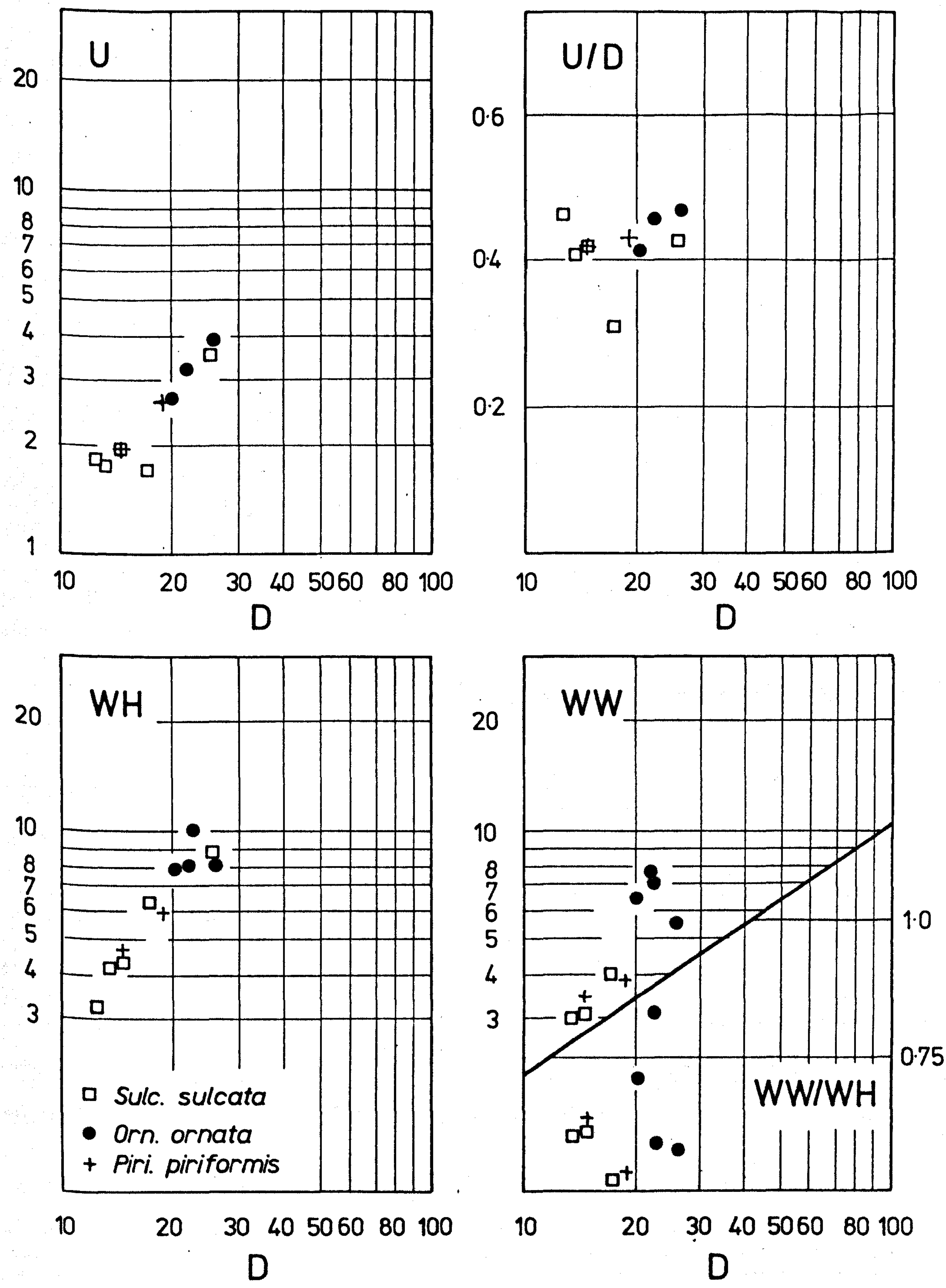


Plat. (Pleuroclymenia) & Plat. (Trigonoclymenia)



Textfig. 5.16

Subfam. nov. α (:*Piriclymeniinae*)



Textfig. 5.17 <u>Cyrtoclymenia</u> and <u>Protactoclymenia</u>

<u>Protactoclymenia enkebergensis</u> (Wedekind 1908)

A, growth-line (reversed) at D=37, WW ca 11.5, WH=15.6, x3.33: KW 2062, Enkeberg, Sauerland.

<u>Platyclymenia</u> sp.

B, growth-line (reversed) at D=39, WH=14.2, x3.33: KW 2071, Beil, Sauerland.

<u>Cyrtoclymenia involuta</u> (Wedekind 1908)

C, growth-line at D=35, WW=15.7, WH=17.3, x3.33: KW 2096, Beringhausen, Sauerland. D, growth-line at D=15, x6.66: KW 2059, Beil, Sauerland. E, cross-section at D=27 (maximum), x3.33: HU P82.4, Beringhausen, Sauerland.

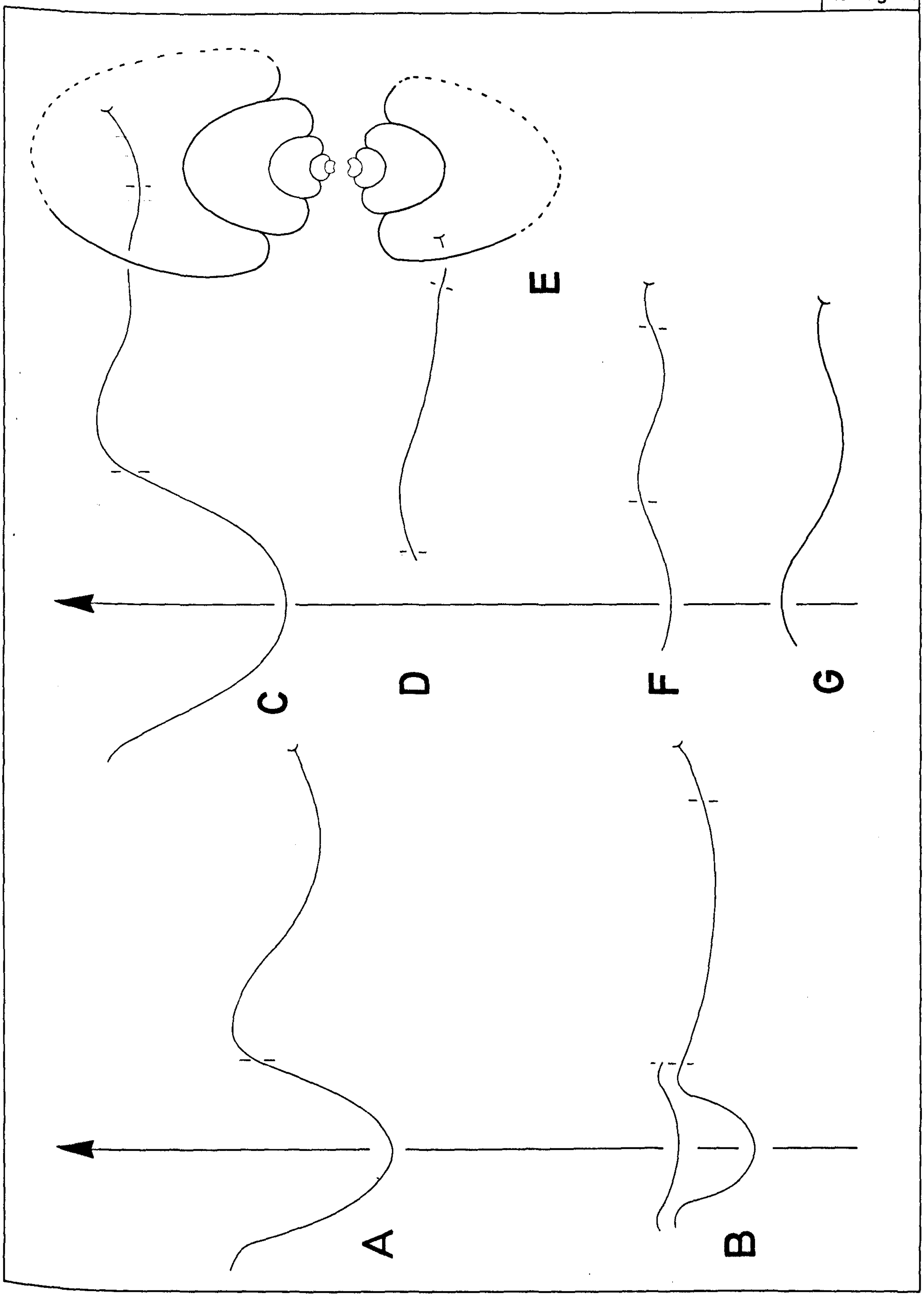
<u>Cyrtoclymenia angustiseptata</u> (Münster 1832)

F, suture at D=36, x3.33: BSP AS VII 585, Münster Collection, Schübelhammer, Oberfranken.

<u>Cyrtoclymenia plicata</u> (Münster 1839)

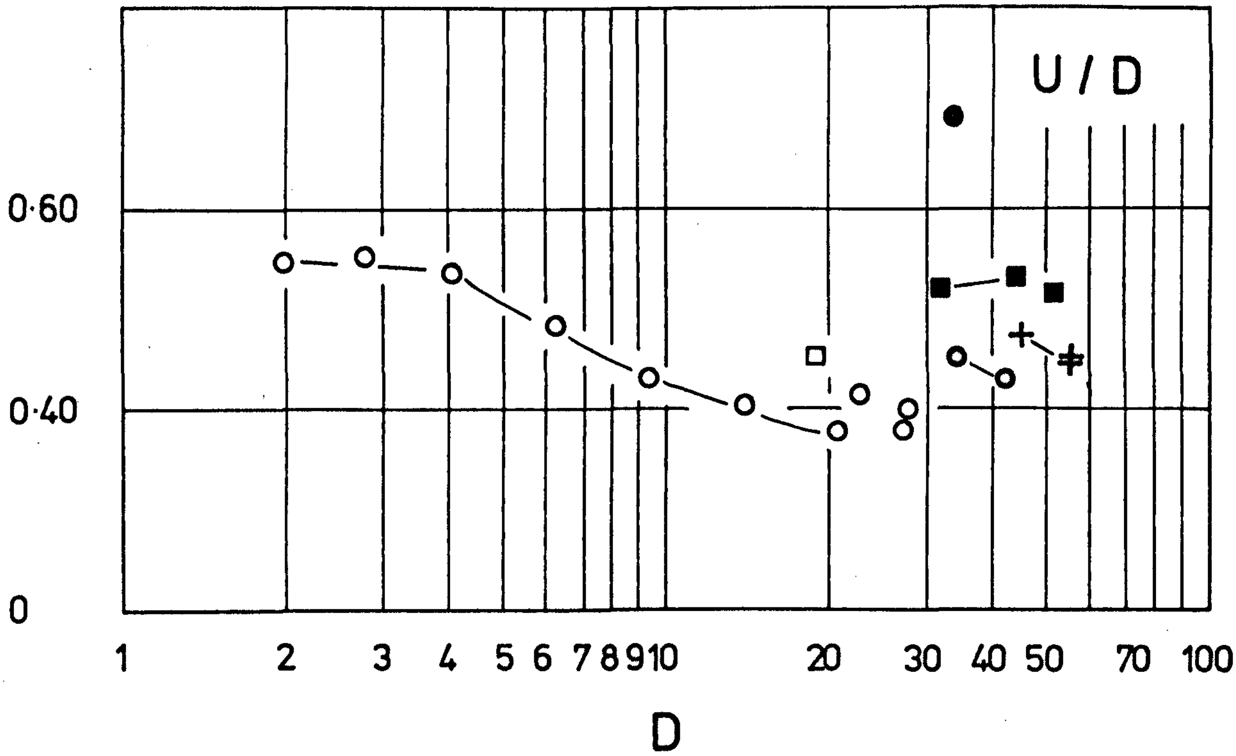
G, suture (reversed) at D ca 62, x1.66: BSP AS VII 584, Münster Collection, Schübelhammer, Oberfranken.

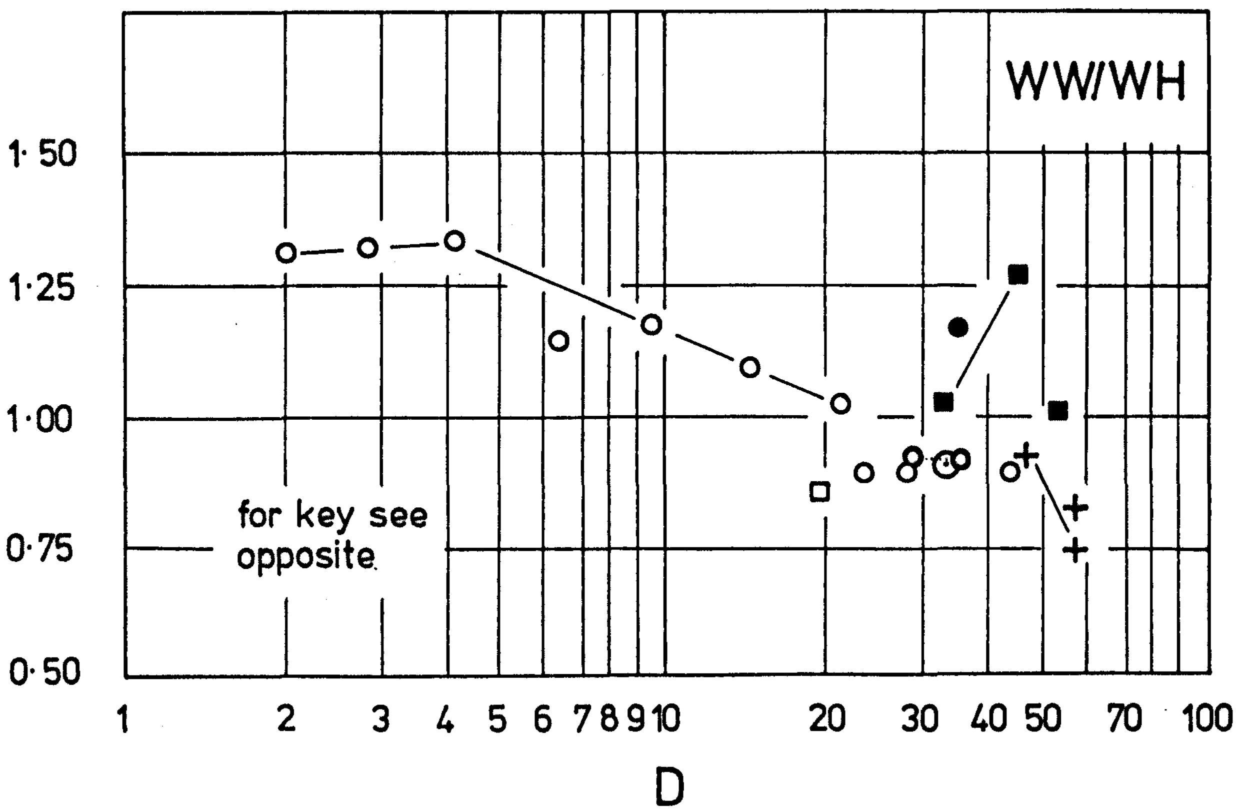
Textfig. 5.17

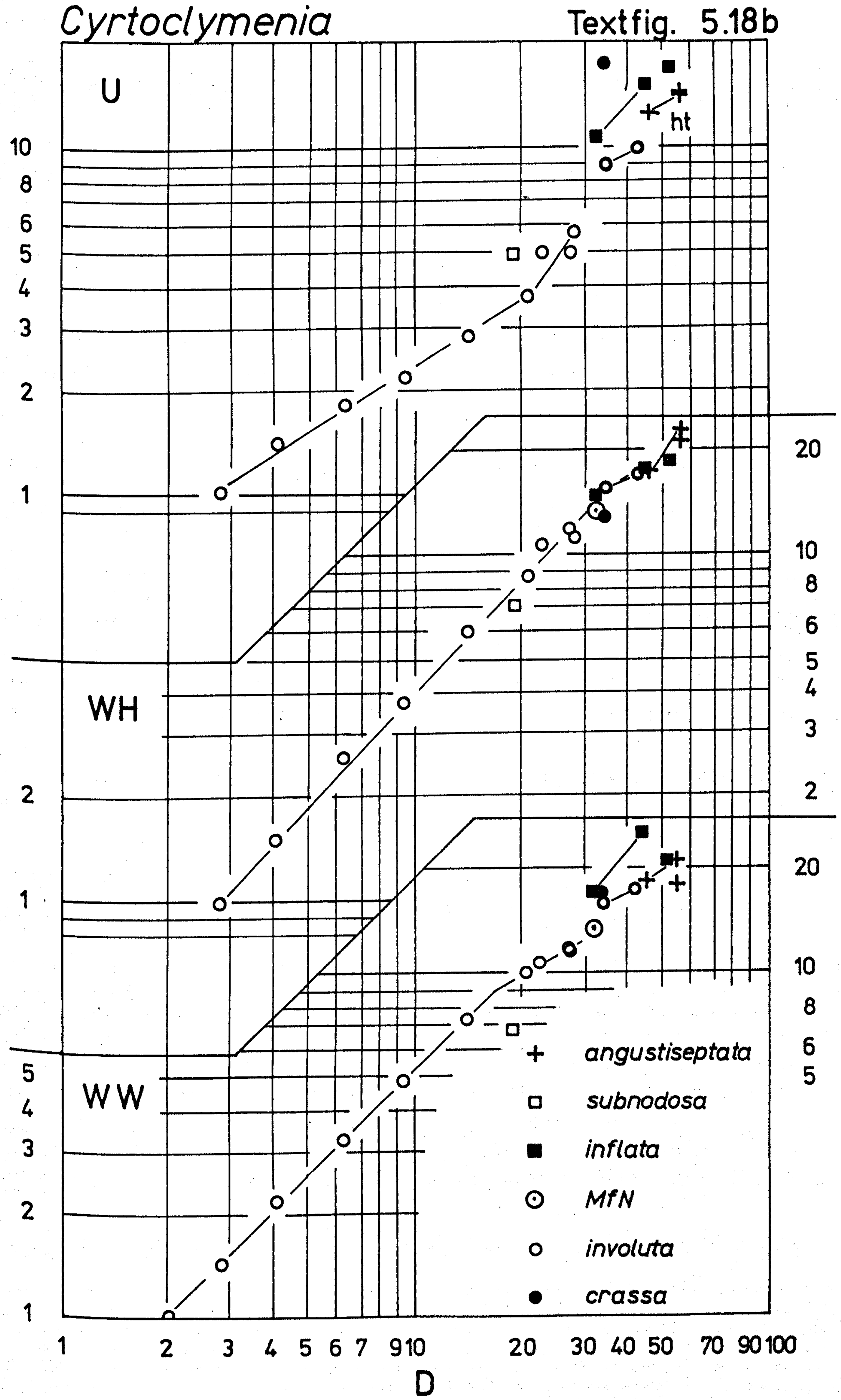


Textfig. 5.18a

Cyrtoclymenia






Cyrtoclymenia
Textfig. 5.18b
U
ht
WH
WW
D
+ angustiseptata
□ subnodosa
■ inflata
⊙ MfN
○ involuta
● crassa
1 2 3 4 5 6 7 9 10 20 30 40 50 70 90 100
10
8
6
5
4
3
2
1
20
10
8
6
5
4
3
2
1
20
10
8
6
5
5
4
3
2
1

Textfig. 5.19

Gen. Nov. F <u>stuckenbergi</u> (Tokarenko 1903)

A, suture at D ca 15, WW=6, x6.66: GT 2016, Beil, Sauerland. B, rib at D=21, x6.66: KW 2058, Beil, Sauerland.

C, cross-section at D=20, x3.33; GT 2016, Beil.

Gen. Nov. F <u>costata</u> (Münster 1842)

D, rib at WH=7.3, x6.66, suture at WH=5.2, x6.66: BSP AS VII 606, Münster Collection, Geiser, Oberfranken. Figured by Münster 1842 (pl. XI, figs. 16a-b).

Gen. Nov. D <u>subflexuosa</u> (Münster 1840)

E, growth-line (reversed) D=18, WW=3.9, WH=8.5, x6.66; F, cross-section at D=15.9, x3.66: BSP AS VII 526, Münster Collection, Geiser, Oberfranken. Figured by Münster 1840 (pl. XV, fig. 10).

Gen. Nov. D sp.

G, growth-line and suture (both reversed) at D=60, x3.33: KW 2076, Beil, Sauerland.

<u>Protornoceras</u> sp.

H, growth-line at D=30.5, WW=8.2, WH=13.7 and suture (reversed) at WW=5.9, WH=7.7, x3.33: RE 551 734.5 A242/1, Torley Collections Enkeberg, Sauerland.

<u>Carinoclymenia</u> <u>beuelensis</u> (Lange 1929)

J, suture (reversed) at WW ca 4, WH=11, x8: MfN 5536, Müller Collection, Bed 1, Alte Heerstrasse, Schleiz. Figured by Müller 1956, fig. 8. K, growth-line (reversed) at D ca 43, WW=6.7, WH=24.8, x3.33: KW 2070, Beil, Sauerland. L, cross-section at D=15, x3.33: GT 2023, Beil, Sauerland.

Gen. Nov. E sp. <u>a</u>

M, growth-line at WW=9, WH=18, and suture (reversed) at WW=10.9, WH=23, x3.33; N, cross-section at D=62, x1.5: Mbg, Schindewolf Collection, La Serre, Cabrieres. Figured by Schindewolf 1923b, fig. 4f.

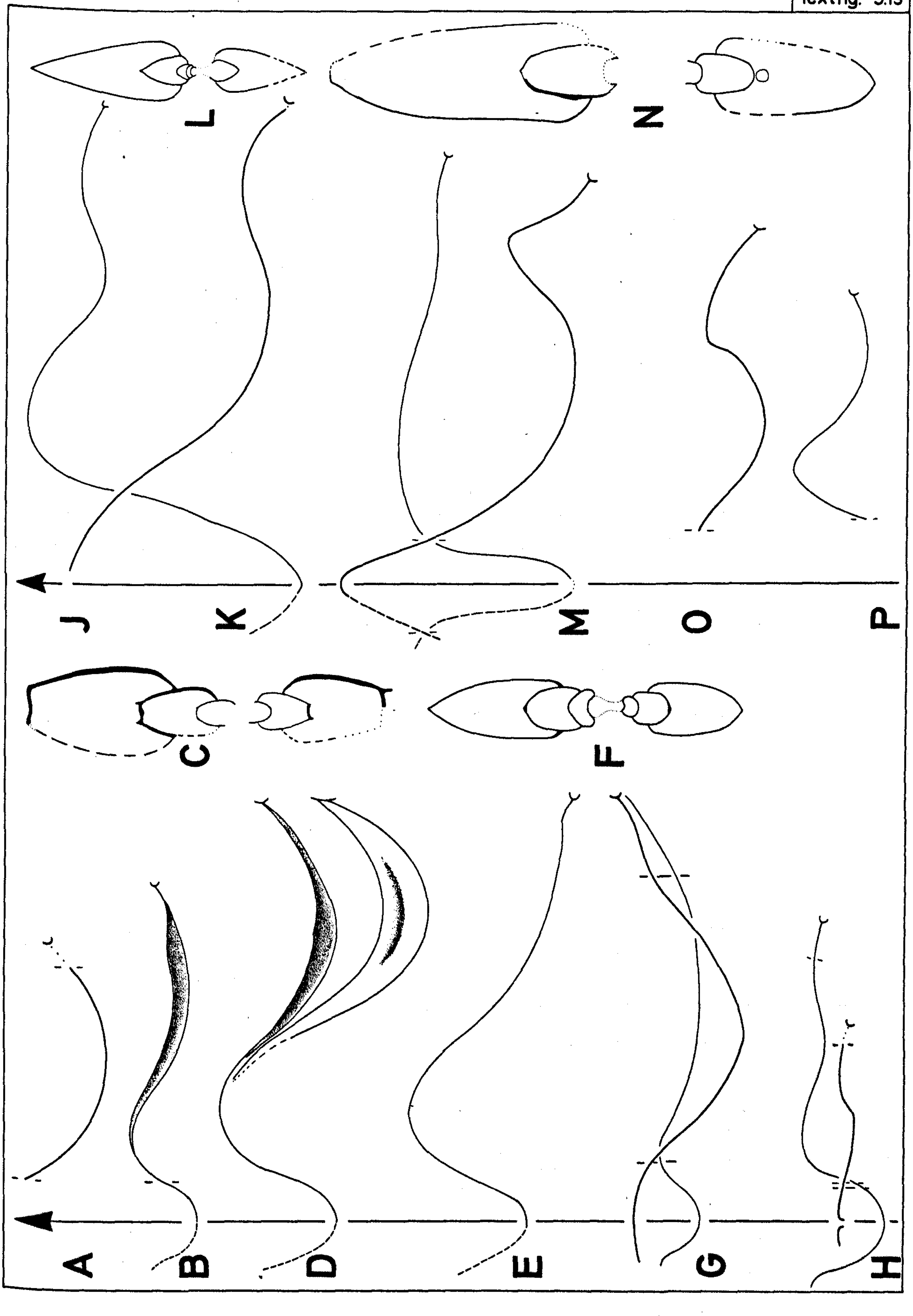
Gen. Nov. E sp. <u>b</u>

O, suture (reversed) at WH=5.5, x10: BSP AS VII 528, Münster Collection, Geuser, Oberfranken.

Gen. Nov. F <u>falcifera</u>

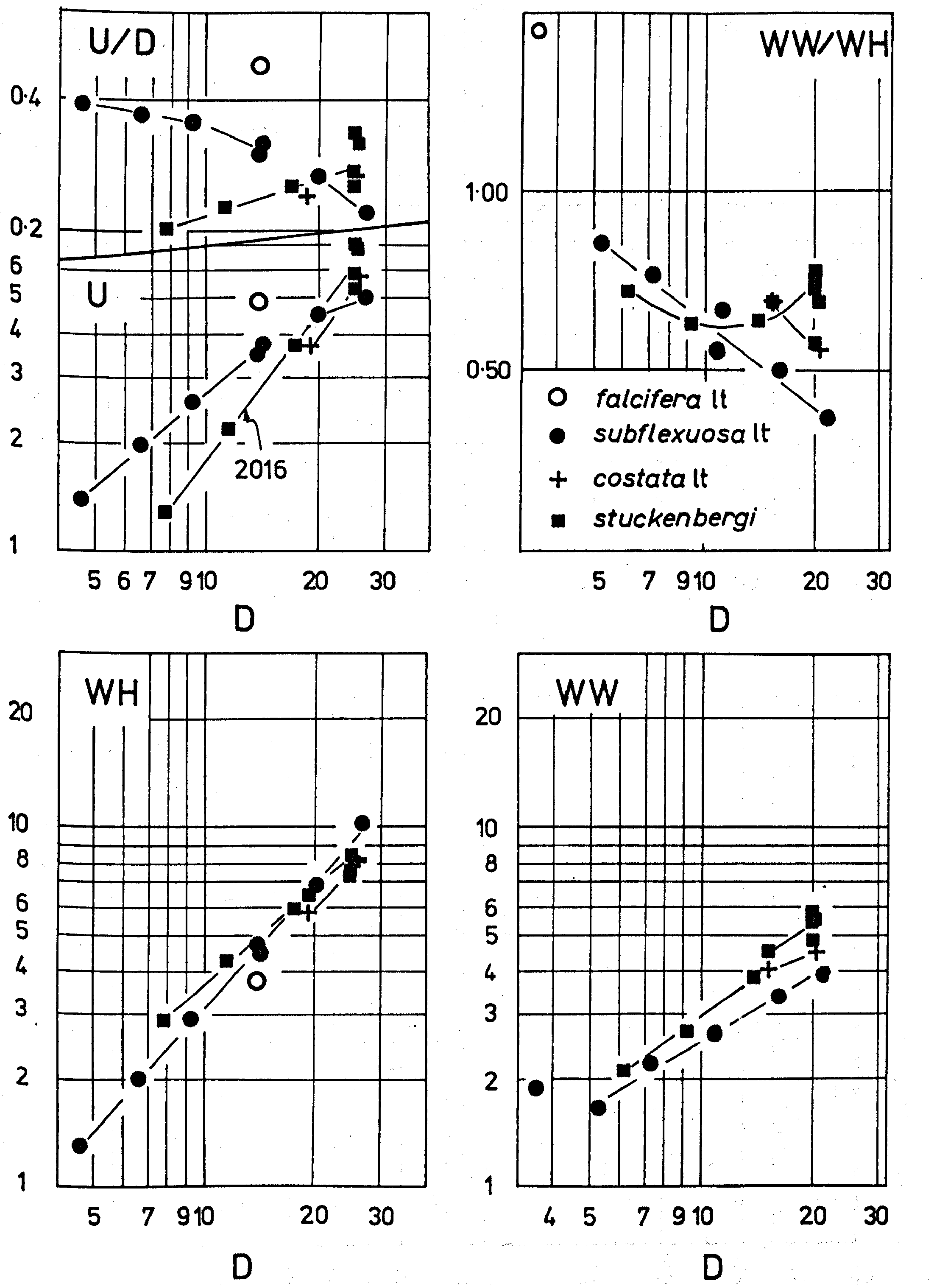
P, growth-line (reversed) at D=10, x4: BSP AS VII 533, Münster Collection, Geuser, Oberfranken.

Textfig. 5.19

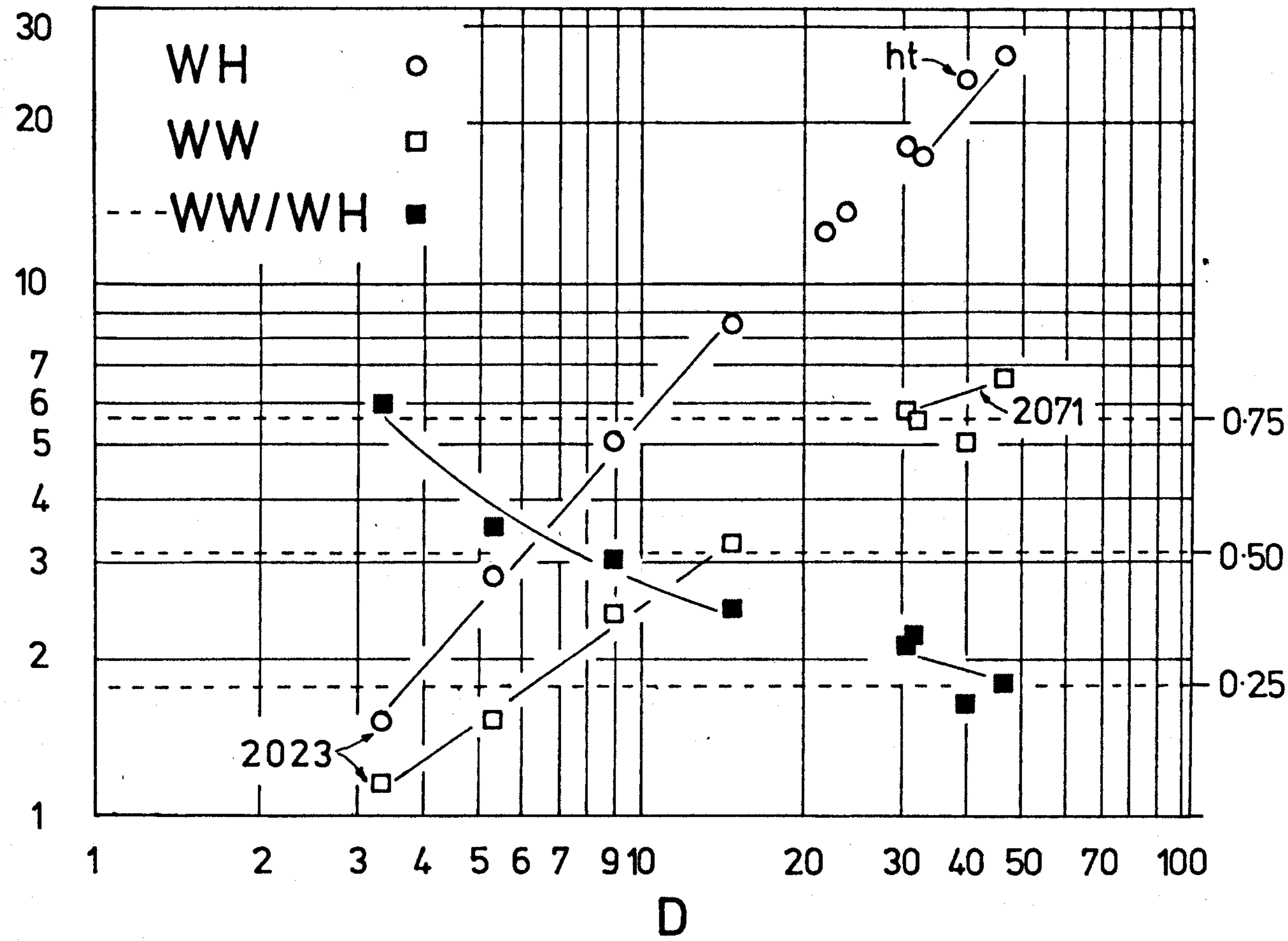


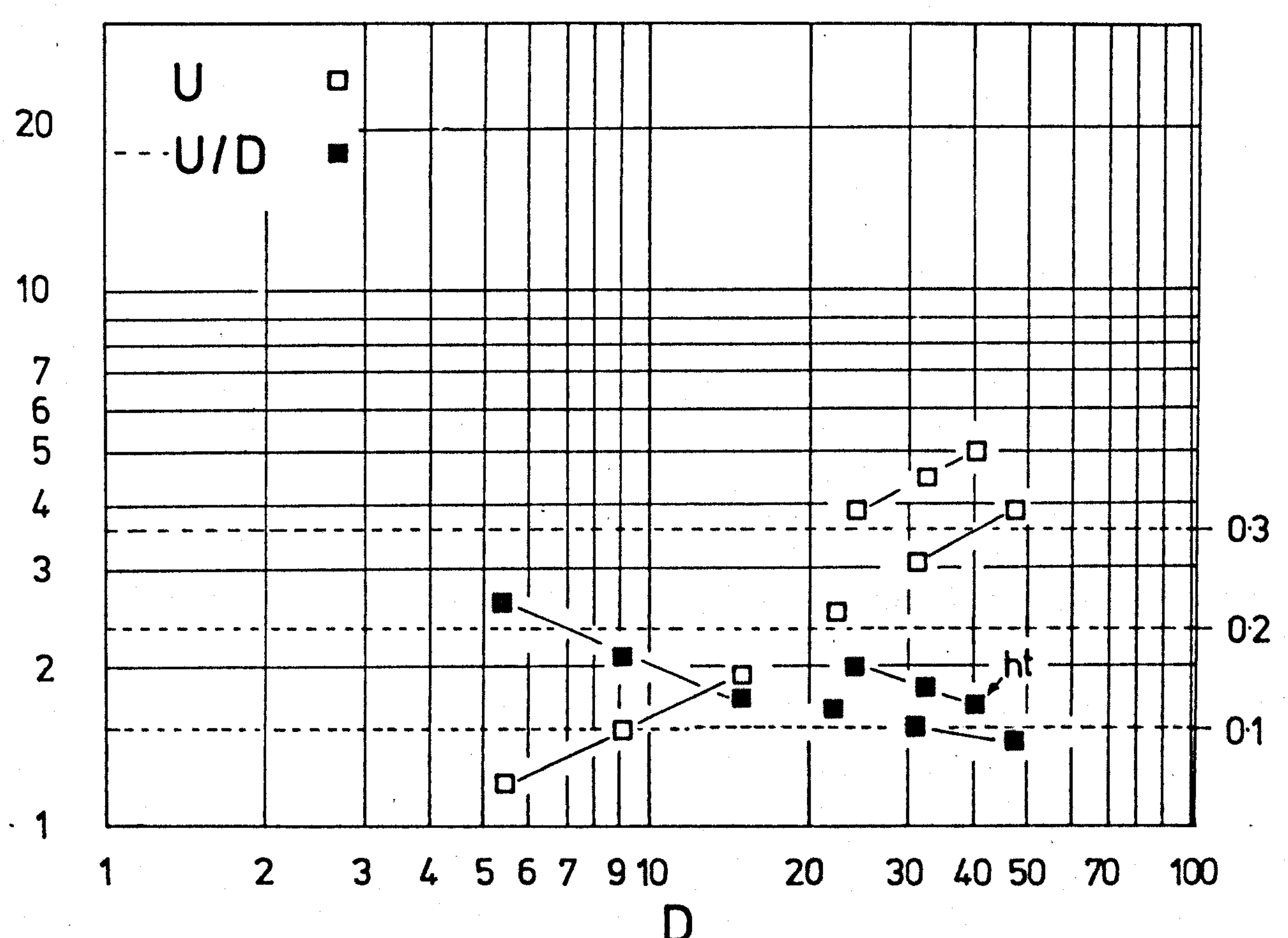
Textfig. 5.20

Gen. Nov. F



Carinoclymenia beuelensis





Textfig. 5.22 Clymenia

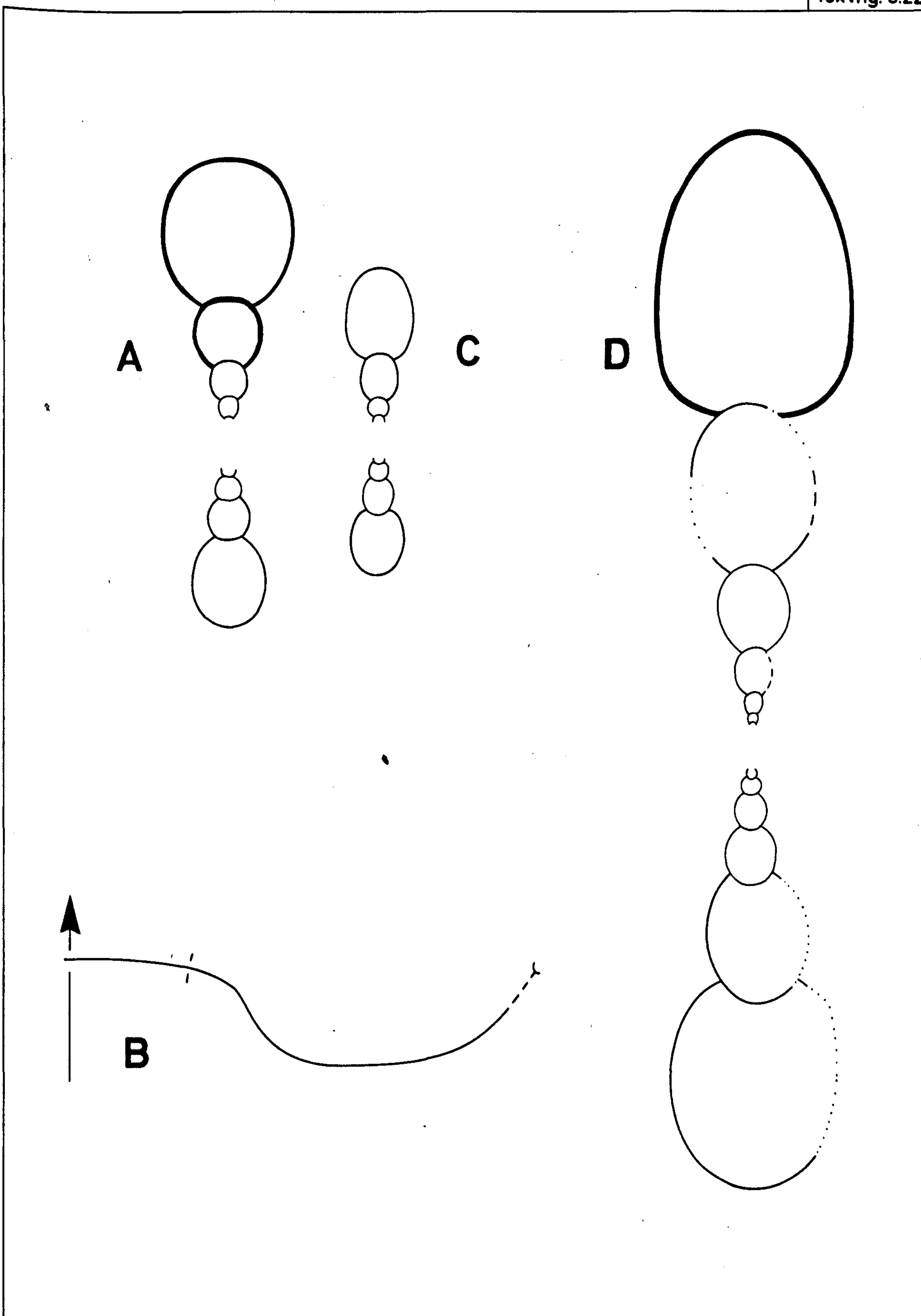
Clymenia laevigata (Münster 1839)

A, cross-section at D=43, x2: SM H10365; B, suture at D=30, x6.66; C, cross-section at D=81, x0.66: SM H10366, lectotype, Münster Collection, Schübelhammer, Oberfranken.

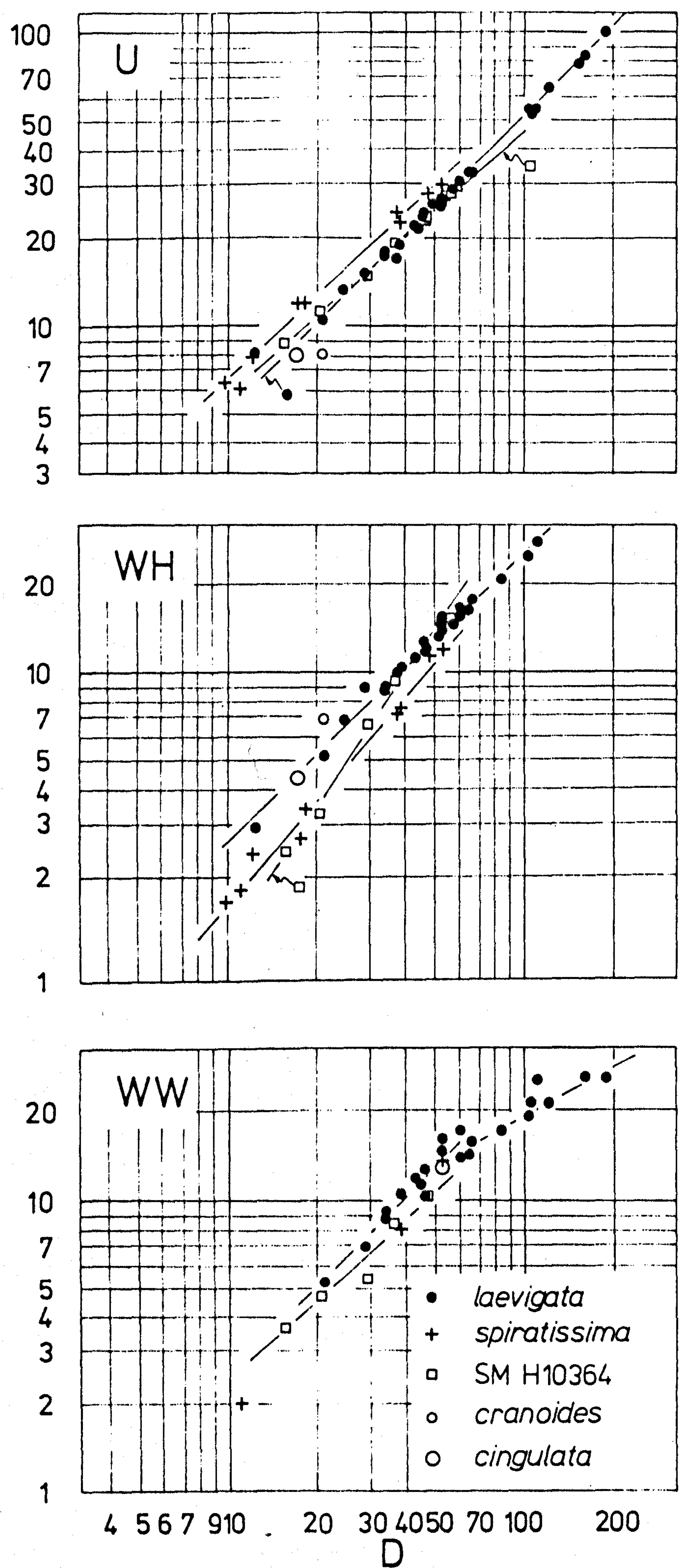
Clymenia aff. spiratissima (Schindewolf 1923a)

D, cross-section at D=49, x3.66: SM H10364, Münster Collection, Schübelhammer, Oberfranken.

Textfig. 5.22

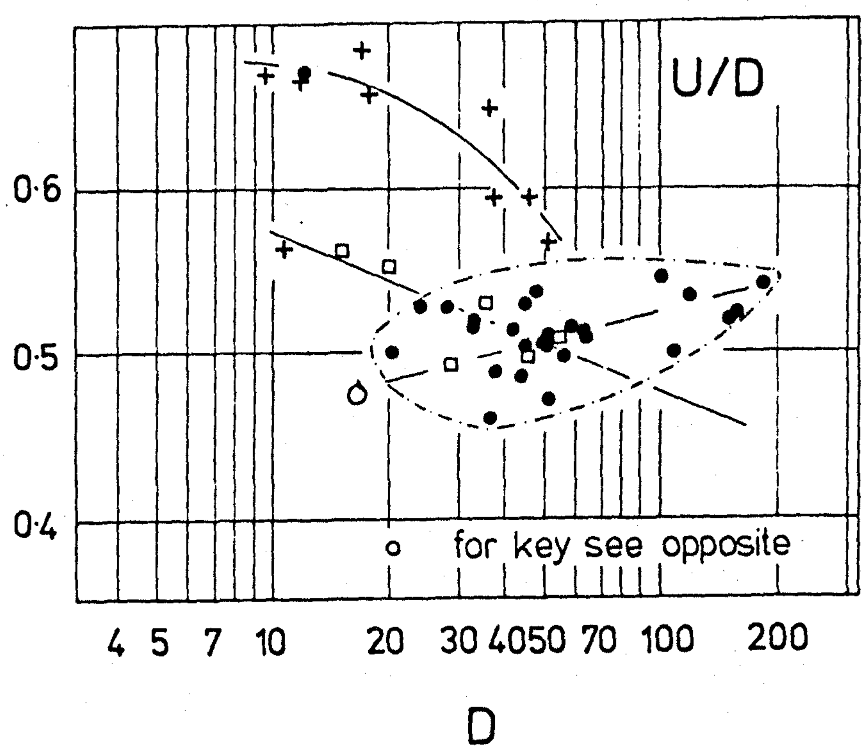


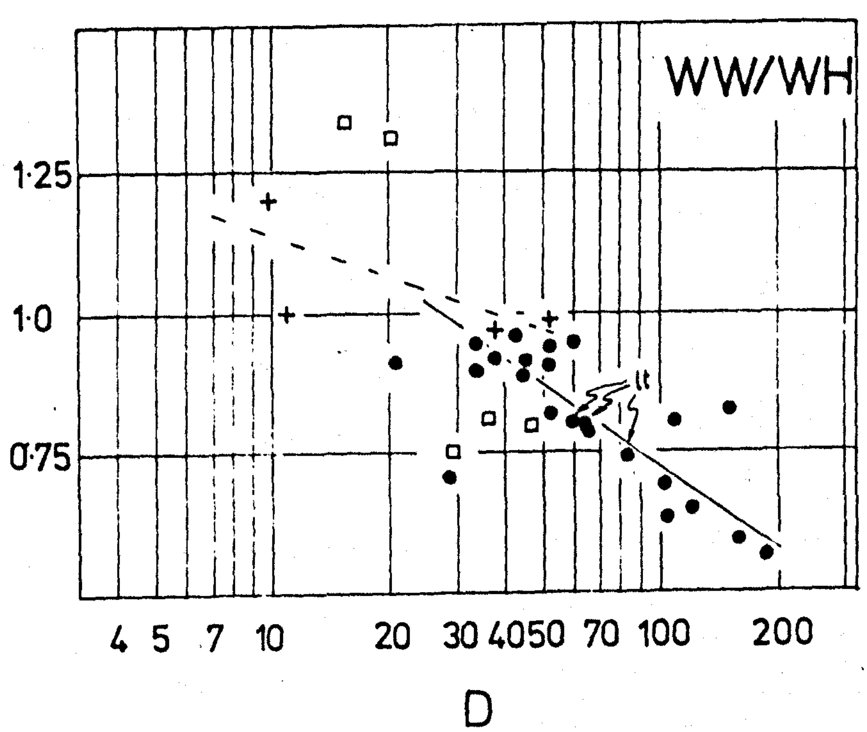
Textfig. 5.23a *Clymenia*



Clymenia

Textfig. 5.23b





Textfig. 5.24 Kosmoclymenia and Protoxyclymenia

Kosmoclymenia undulata pattisoni Selwood 1960

A, suture and B, growth-line at D=48, WH=17, x3.33: GSM 87043, Stourscombe Beds, Cornwall. Holotype of Kosmo. pattisoni Selwood (1960, pl. 27, fig. 1).

Kosmoclymenia sublaevis (Münster 1832)

C - E, sutures (reversed) at WW=6.1, WH=5.9, x13.33, WW=3.3, WH=2.4, x13.33 and D=3.8, WW=1.4, WH=0.9, x16.66; 78D 1125.1, Korn Collection, Bilsteinhöhle, Warstein.

Kosmoclymenia colubrina (Lange 1929)

F,G, growth-lines at WH=10.7 and WH=7.8, both x6.66; KW 2081, Dasberg, Sauerland.

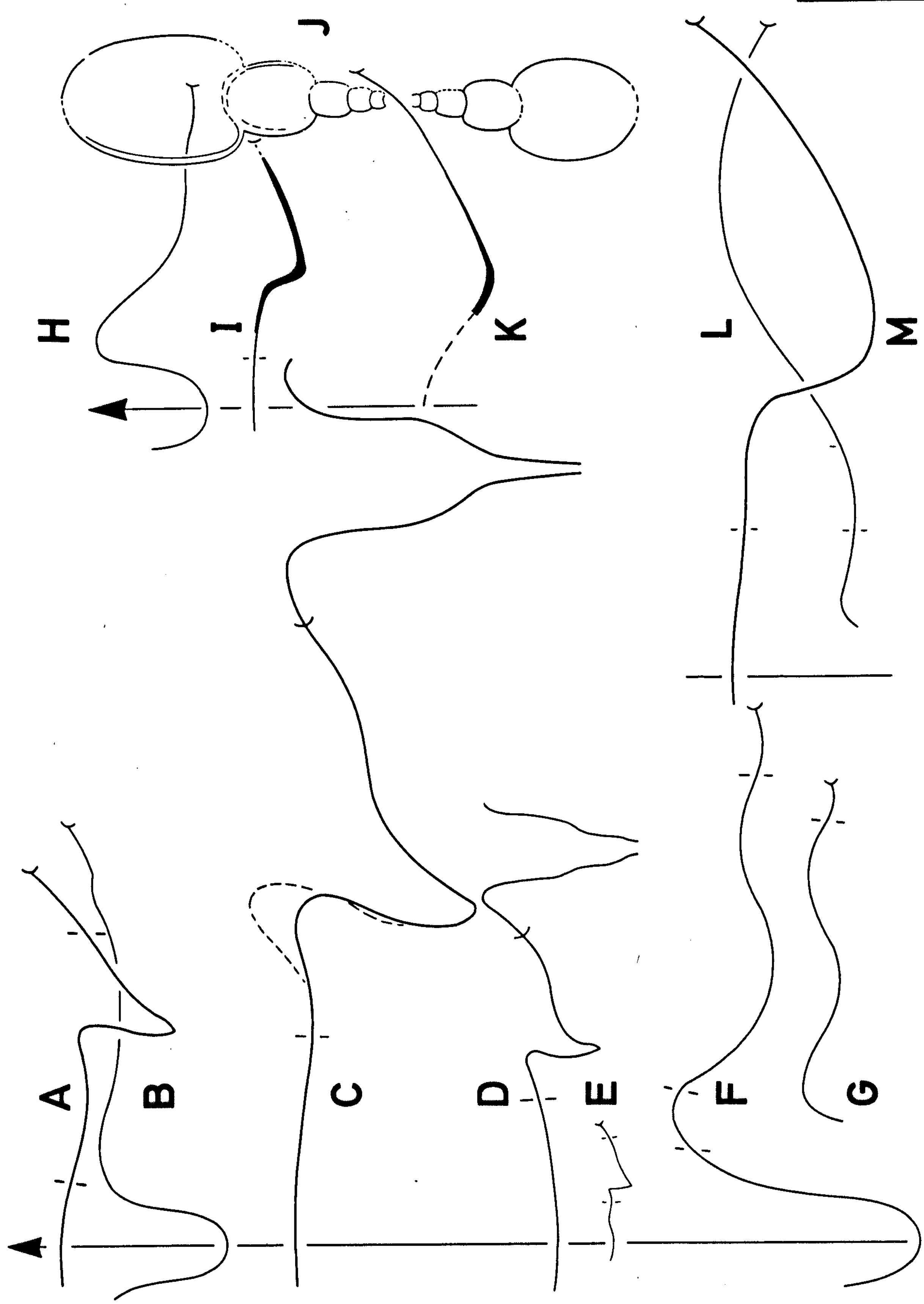
Protoxyclymenia dunkeri (Münster 1839)

H, growth-line at WW=5.1, WH=6.9, x6.66; I, suture (reversed) at WW=4.6, WH=6.1, x6.66; J, cross-section at D=30, x3.33: 81D 6403.2, Korn Collection, Wäschholz, Oberfranken; K, penultimate suture (reversed) at WH=5.5, x6.66, BSP AS VII 559, lectotype, Gattendorf, Oberfranken.

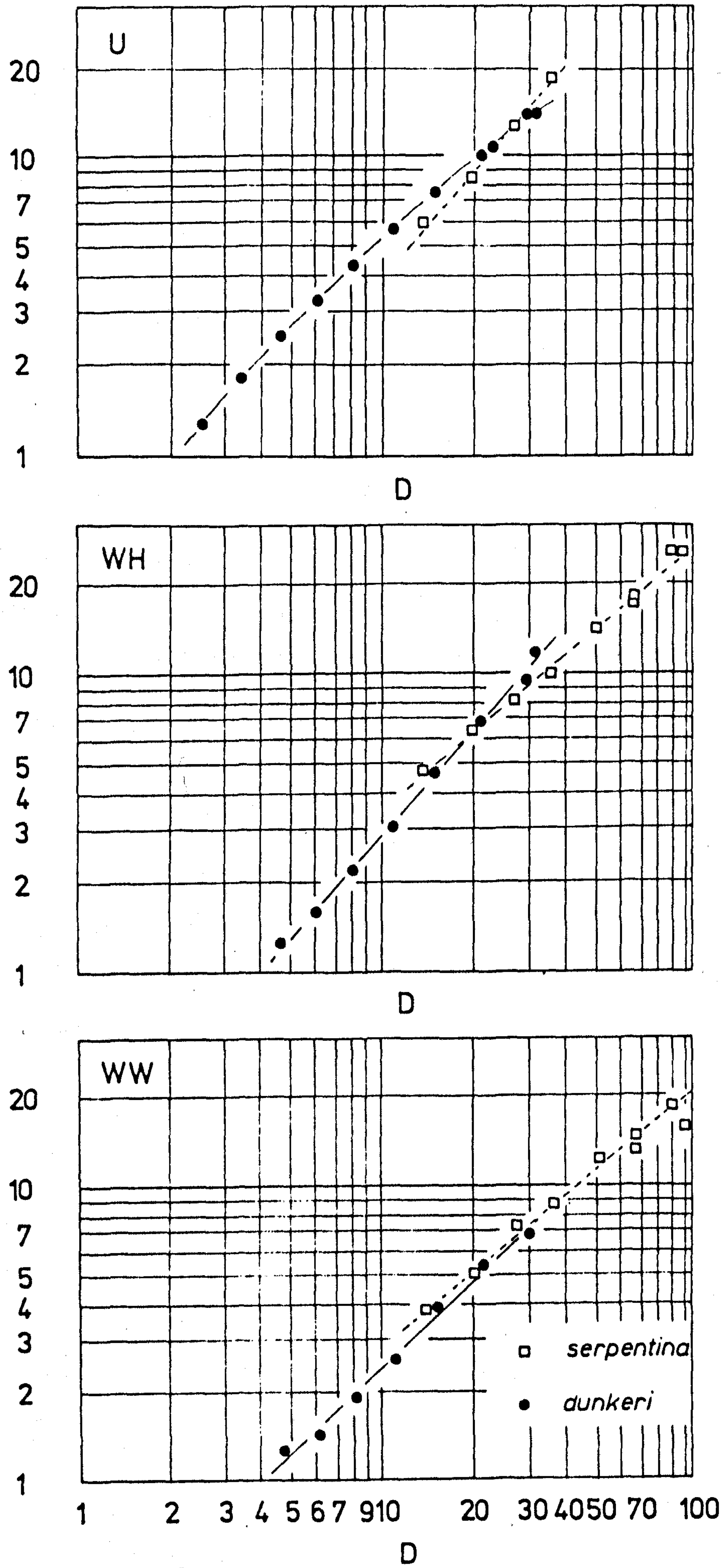
Protoxyclymenia serpentina (Münster 1832)

L, growth-line and M, suture (both reversed) at WW ca 10, WH=14, x6.66, KW 2077, Beil, Sauerland.

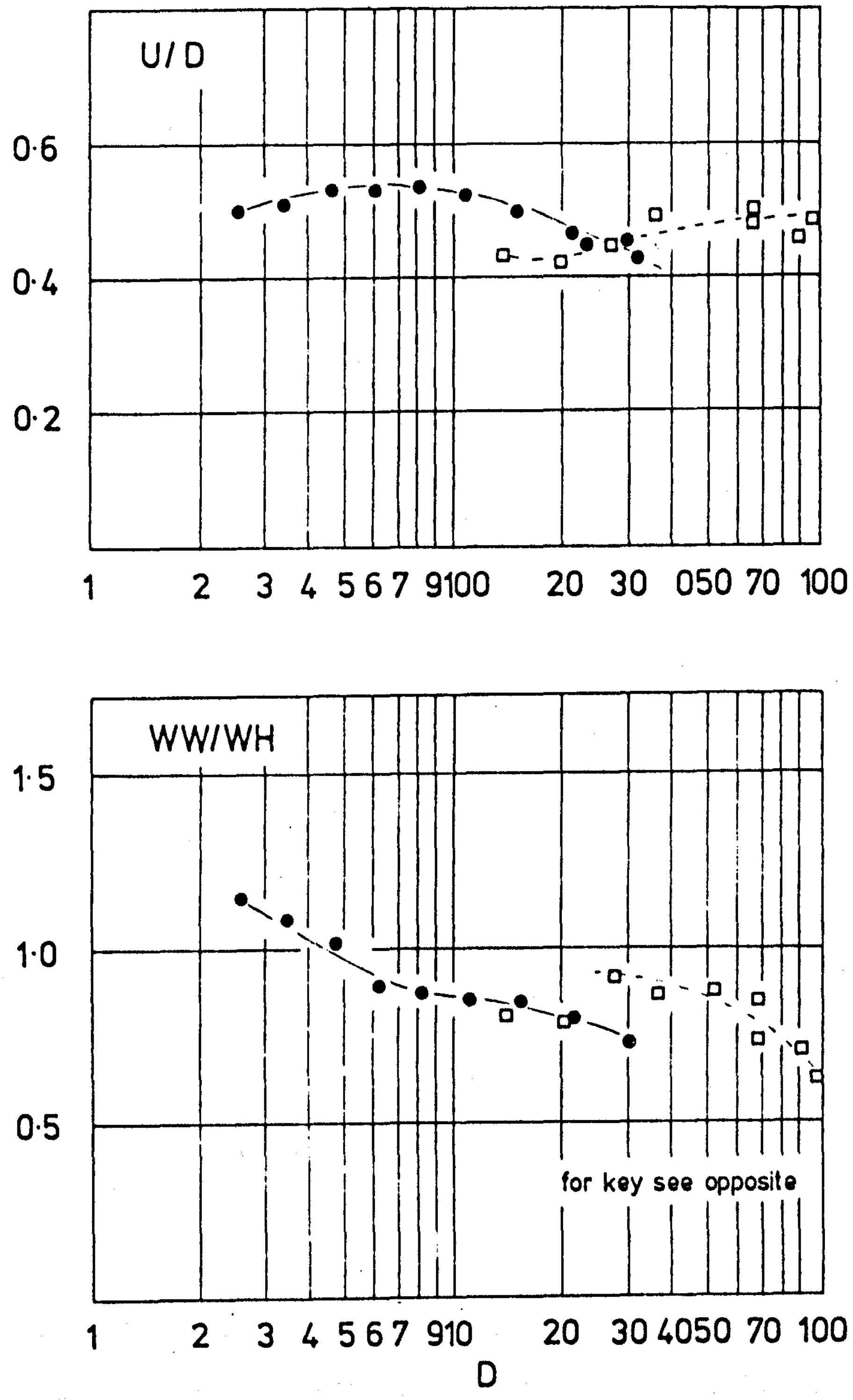
Textfig. 5.24



Textfig. 5.25a *Protoxyclymenia*



Protoxyclymenia Textfig. 5.25b



Textfig. 5.26 Kosmoclymenia and Protoxyclymenia

Protoxyclymenia dunkeri (Münster 1839)

A, suture at WH=5.5, x7.5: lectotype, BSP AS VII 559, Münster Collection, Gattendorf, Oberfranken.

Kosmoclymenia

B, Kosmo. sp. suture at WW=5.5, WH=8.9, x7.5: specimen from the lower Wocklumeria Stufe, Bilstein, Warstein. Dotted area represents the width of the septum where it is attached to the inner side of the shell wall.

Kosmoclymenia (Group I)

C, Kosmo. subundulata (Wedekind 1914), growth-line at WW=8, WH=12, x7.5: MfN c597, Schindewolf Collection, Ense, Wildungen, Kellerwald.

Kosmoclymenia (Group II)

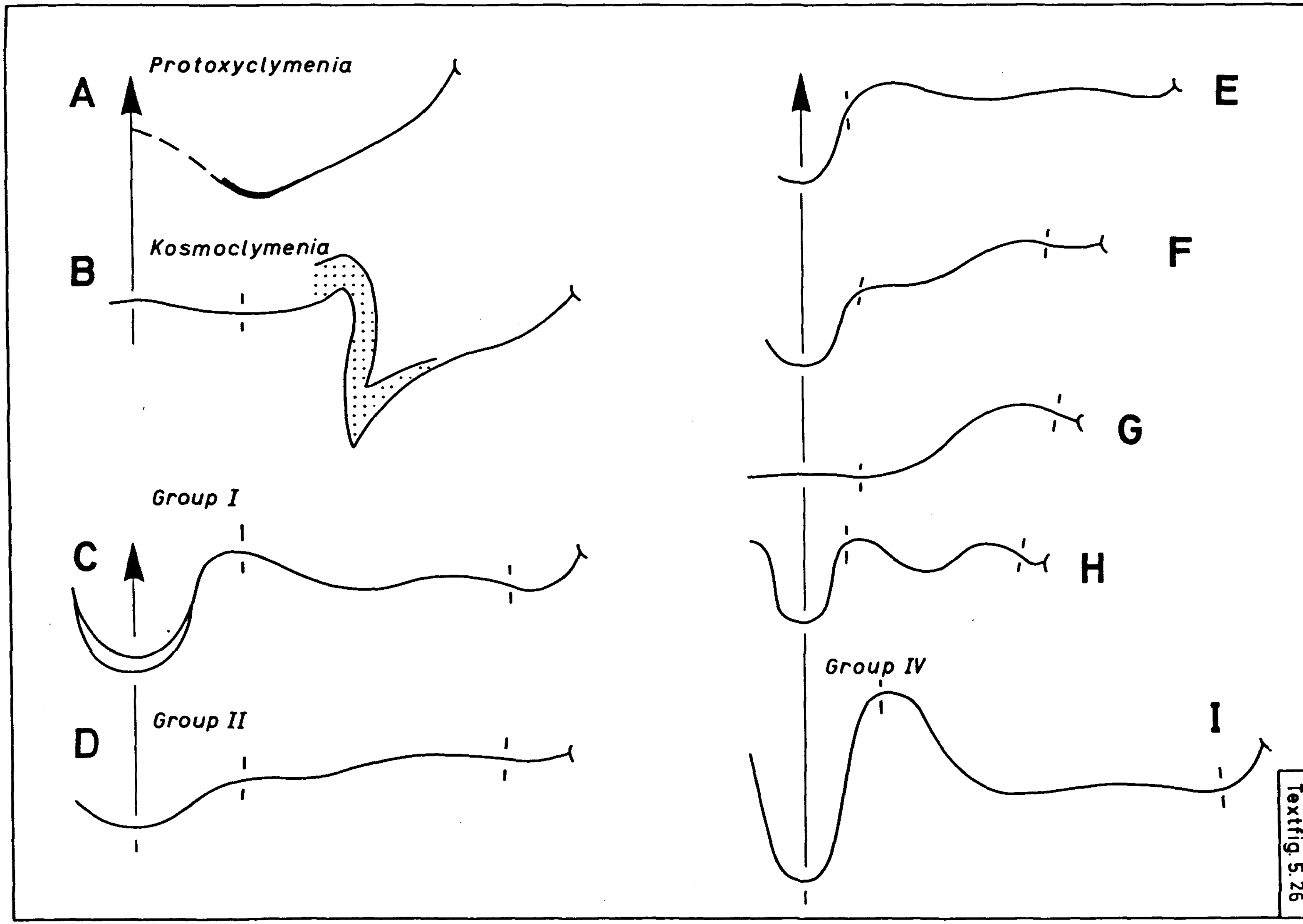
D, Kosmo. sp. g, growth-line at D=50, WW=12, WH=14, x10: MfN c554, Dzikowiec, Poland. E, Kosmo. aff. sublaevis (Münster) growth-line at D=45, WW=13, WH=15.5: NWGL, Ostprovinzial Steinbruch, Drewer. F, Kosmo. sp. d, growth-line at D=20.5, WW=4.8, WH=5.5, x7.5: UEN 80, Münster Collection, Schübelhammer, Oberfranken. G, Kosmo. sp. e, growth-line at D=23.2, WW=4.7, WH=5.9, x7.5: SM H10399, Münster Collection, Schübelhammer, Oberfranken.

Kosmoclymenia (Group III)

H, Kosmo. aff. sp. h, growth-line at WW=4.1, WH=5.5, x7.5: SM H10400, Münster Collection, Schübelhammer, Oberfranken.

Kosmoclymenia (Group IV)

I, Kosmo. sp. i, growth-line (reversed) at D=26, WW=7.1, WH=8.9, x10: MfN c595, Beyrich Collection, Dzikowiec, Poland.


Textfig. 5.26
A
Protoxyclymenia
B
Kosmoclymenia
C
Group I
D
Group II
E
F
G
H
I
Group IV

Textfig. 5.27 Kosmoclymenia

Kosmoclymenia undulata (Münster 1832)

A, cross-section at D=76, x3.33: SMF, proposed neotype, Bed 23, Reigern Quarry, Sauerland. D, cross-section at D ca 53, x3.33: HU P82.11, ?Bed 33 Reigern Quarry, Sauerland. E, growth-line at WH=15, x3: HU P82.7, ?Bed 33, Reigern Quarry, Sauerland.

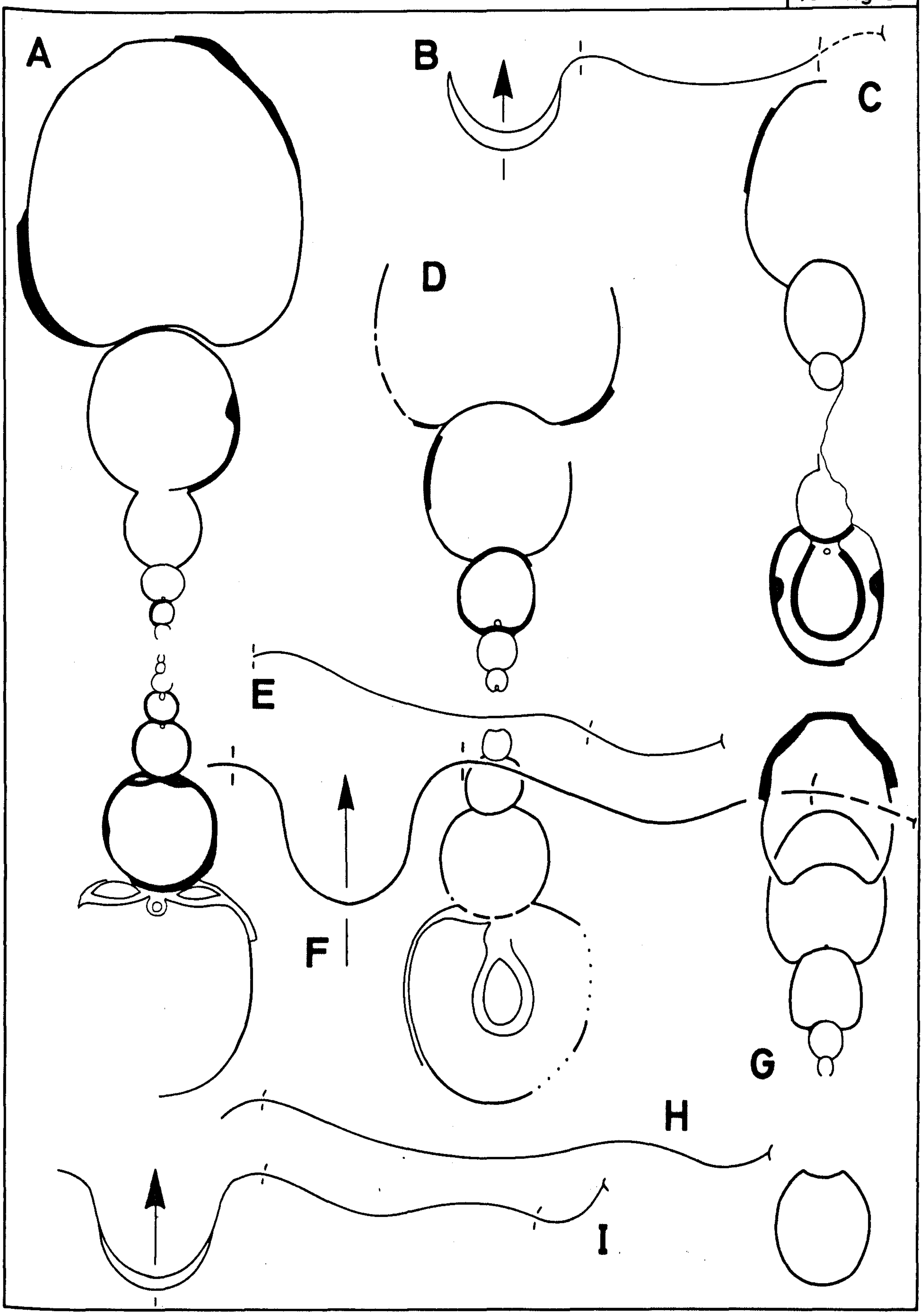
Kosmoclymenia subundulata (Wedekind 1914)

B, growth-line at WW=8, WH ca 7, x6.66. C, cross-section at D=42.5, x4: SM H10390, Münster Collection, Schübelhammer, Oberfranken. H,I, growth-lines at D=38, WW ca 11 and WH= 13.4, and WW ca 9, WH=11.2, x6.66: MfN c597, Schindewolf Collection, Ense, Wildungen, Kellerwald. Figured by Schindewolf (1957, fig. 41.8).

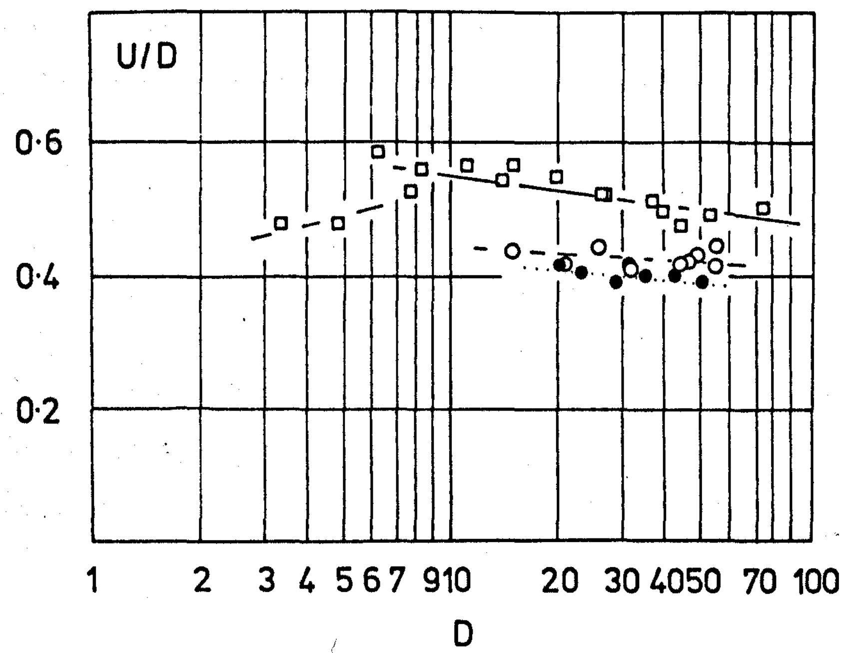
Kosmoclymenia inaequistriata (Munster 1832)

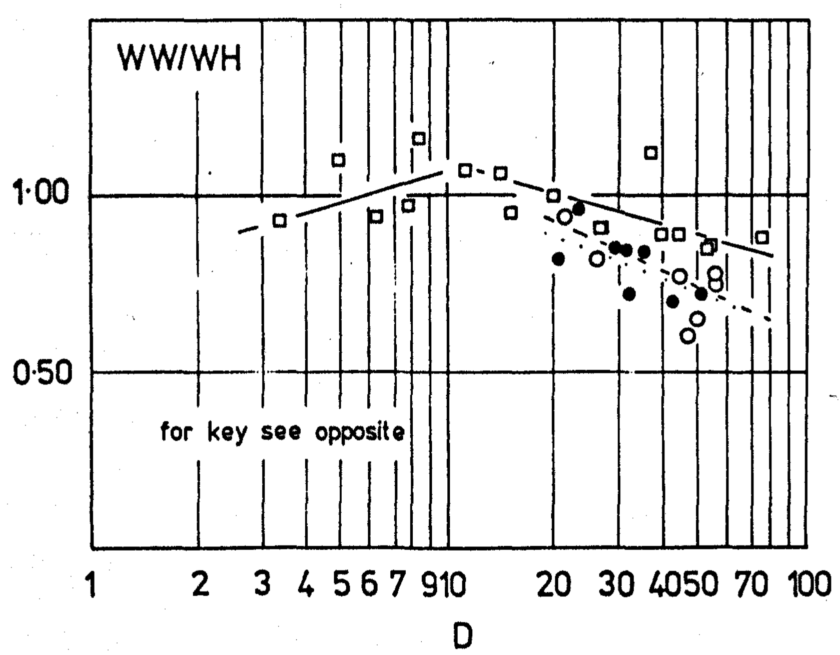
F, growth-line at WW=9.5, WH=10.6, x7.66, G, cross-section at D=42, WW ca 12, WH=15.9 (maximum) x2, and inset body chamber cross-section at WW=13, WH=16.5, x2: SM H10376, proposed neotype, Münster Collection, Schübelhammer, Oberfranken.

Textfig. 5.27

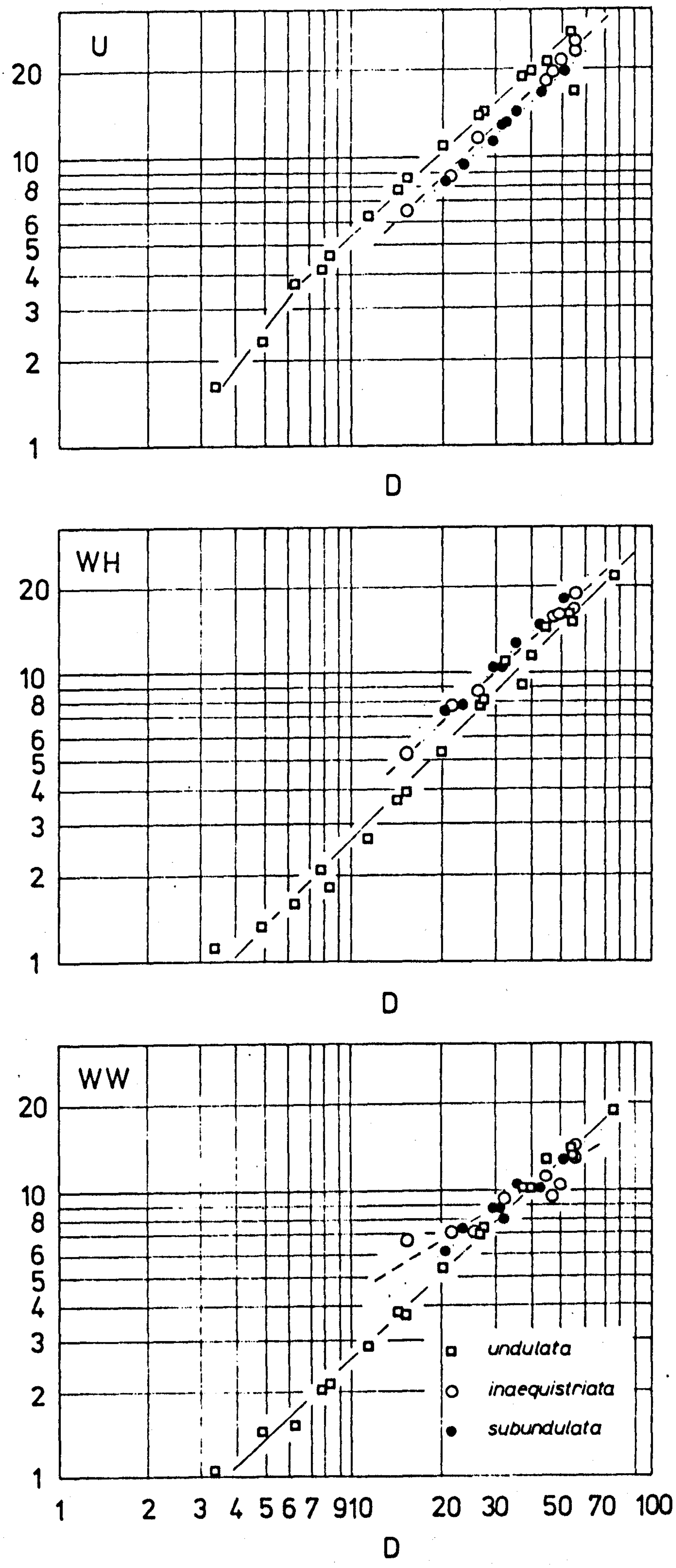


Textfig. 5.28a *Kosmoclymenia*





Kosmoclymenia Textfig. 5.28b



Textfig. 5.29 Kosmoclymenia and Protoxyclymenia

Kosmoclymenia aff. bisulcata (Münster 1840)

A,C, growth-lines at WW=10.5 and one whorl prior to this, x8; B, whorl cross-section at WW=11, WH=15.5 (maximum), x3.5: HU P82.12, Reigern Quarry, Sauerland.

Protoxyclymenia serpentina (Münster 1832)

D, growth-line at D=70, x2.5, E, cross-section at D=92, x1.5: BSP AS VII 538, holotype, Münster Collection, Schübelhammer, Oberfranken.

Kosmoclymenia similis (Münster 1839)

F, growth-line at D=23.9, x7.5: Mbg 3133, Bed 20, Schindewolf Collection, Kirch-Gattendorf, Oberfranken.

Kosmoclymenia sp. i

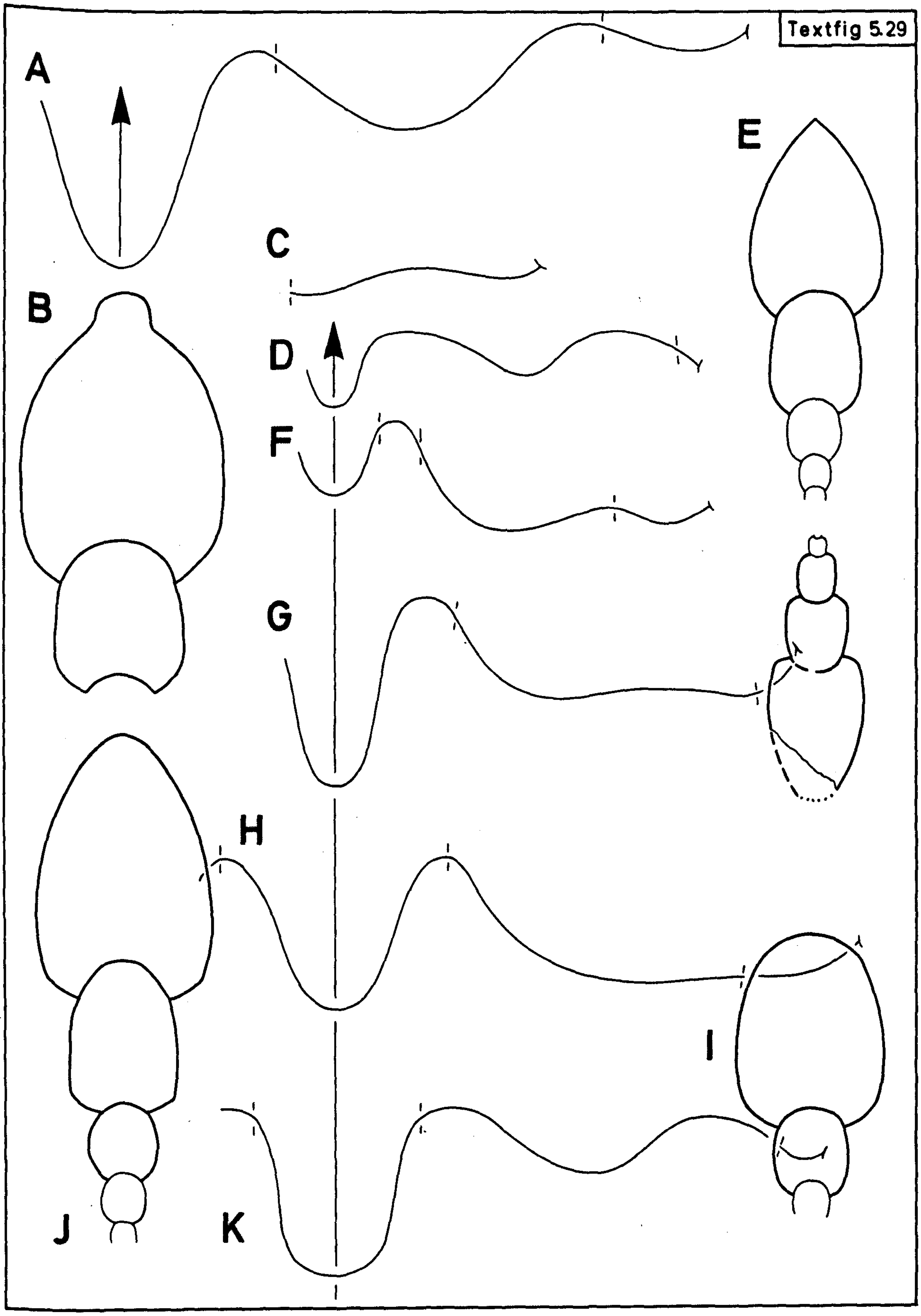
G, growth-line (reversed) at D=26, WW=7.1, WH=8.9, x10.75: MfN c595, Beyrich Collection, Dzikowiec, Poland.

Kosmoclymenia subundulata (Wedekind 1914)

H, growth-line (reversed) at WW=7.2, WH=9.5, x8, I, whorl section at R=15.13, and WW=7.3, WH=9.4 (maximum), x8: SM H10388, Münster Collection, Schübelhammer, Oberfranken.

Kosmoclymenia aff. sp. h

J, cross-section at R=13, x8, K, growth-line at D=21, WW=4.1, WH=5.5, x16: SM H10400, Münster Collection, Schübelhammer, Oberfranken.


Textfig 5.29
A
B
C
D
E
F
G
H
I
J
K

Textfig. 5.30 Genuclymenia

?Genuclymenia sp.

A, growth-line at WW=12.2, x3.33: KW 2067, Wäschholz, Oberfranken.

Genuclymenia frechi (Wedekind 1908)

B, growth-line/rib (reversed), D ca 23, WW=7.9, WH=10.1, x6.66; C, suture, (reversed) at WH=6.2, x6.66: KW 2095, Beringhausen, Sauerland.

Genuclymenia sp.

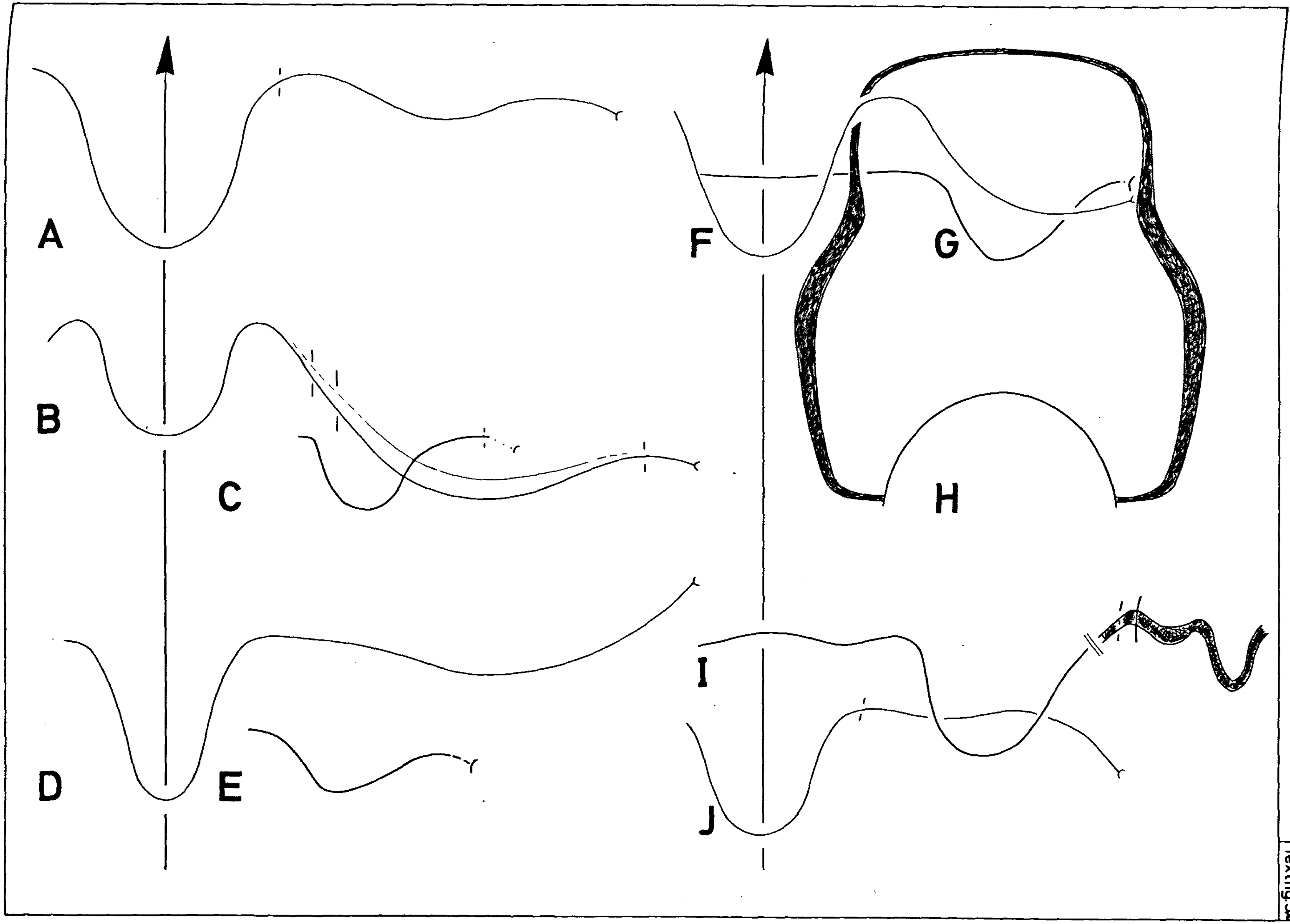
D, growth-line (reversed), at WH=11.8, x6.66; E, suture (reversed) at WH=6.5, x6.66: KW 2066, Wäschholz, Oberfranken.

Genuclymenia quembeli (Wedekind 1908)

F, growth-line (reversed) at WW=6.5, WH=5.5; G, suture (reversed) at WW=7.4, WH=7.6; H, whorl section at WH=11 all x6.66: KW 2061, Wettmarsen, Sauerland.

Genuclymenia aff. karpinskii (Perna 1914)

I, suture (reversed), in two parts, external at WW=5.6, WH=7.5, x10, internal at WW=2.9, WH=3.0, x15; J, growth-line at WW=6.7, WH=8.1, x6.66: 80D 4511.1, Korn Collection, Enkeberg, Sauerland.



Textfig. 50

Textfig. 5.31 Cymaclymenia

Cymaclymenia striata (Münster 1832)

A, growth-line at D=34, WW=9, WH=13.7, x3.66; B, penultimate suture at D=28, WW=7, WH=10, x7.66; C, cross-section at D=35.8, x2.5: SM H10414, proposed neotype, Münster Collection, Schübelhammer, Oberfranken.

Cymaclymenia camerata (Schindewolf 1923a)

D, cross-section at D=39.6, x2.5; E, growth-line at WH=10, x6.66; SM H10415, Münster Collection, Schübelhammer, Oberfranken.

Cymaclymenia sp.

F, suture (reversed) at WW=8, WH=11.5, x4; HU P82.19, House Collection, North Africa; G,H, sutures at WW=1.44, WH=1.88, x20, and WW=0.77, WH=0.76, x26.66; I, eighth suture (reversed) at WW=0.43, WH=0.38, x50: HU P82.18, North Africa.

Cymaclymenia sp.

J, suture at WH=11.5, x5; K, whorl section at WH=11.1, x5: SM H10381, Münster Collection, Schübelhammer, Oberfranken.

Cymaclymenia involvens (Lange 1929)

L, suture at R=13.5, WH=12, x3.33: MfN, paratype, Burg Wocklum, Sauerland. Figured by Lange 1929 (textfig. 24).

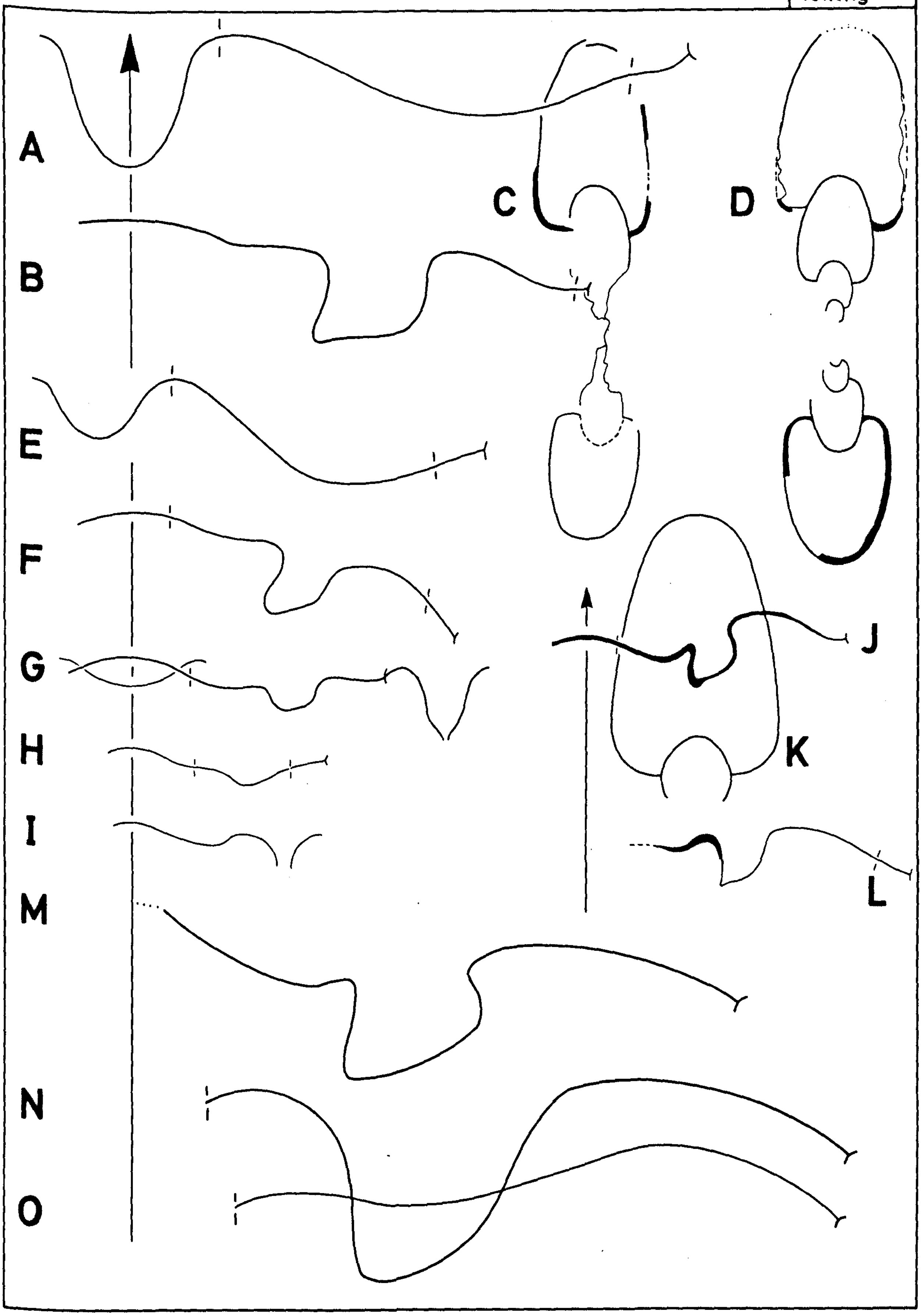
Cymaclymenia evoluta (Schmidt 1924)

M, suture at D=37, x3.3: RE 551 734.5 A373, Paul Collection, labelled "Eβ Bed 21 oberer Abschnitt, Ratingen, Cromford".

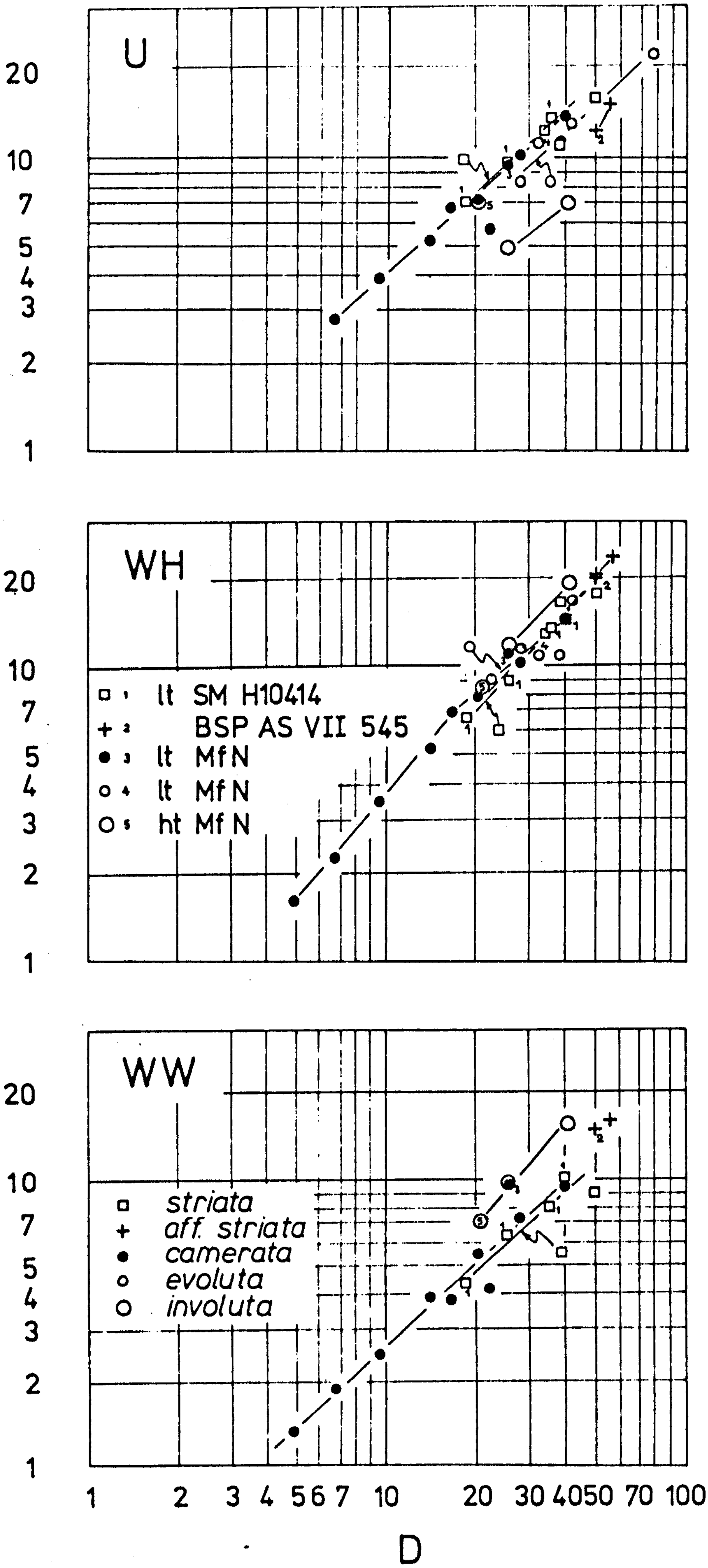
Cymaclymenia cf. evoluta (Schmidt 1924)

N, suture and O, growth-line at D=80, WH=34, x3.33: RE 551 734.5 A371, Paul Collection, labelled "Scharpenhaus, north of Heiligenhaus".

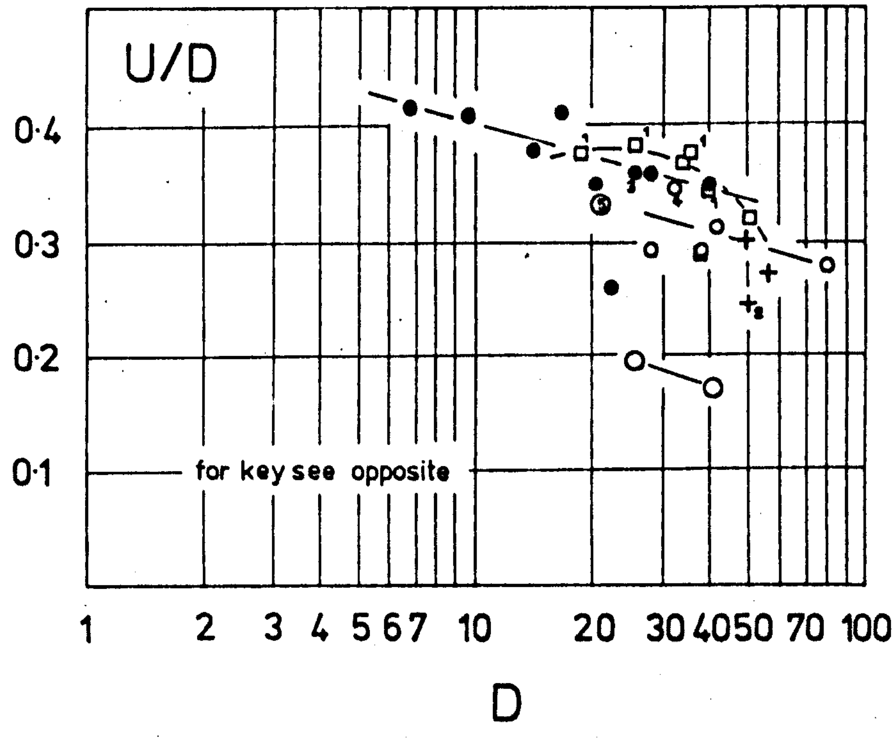
Textfig 5.31

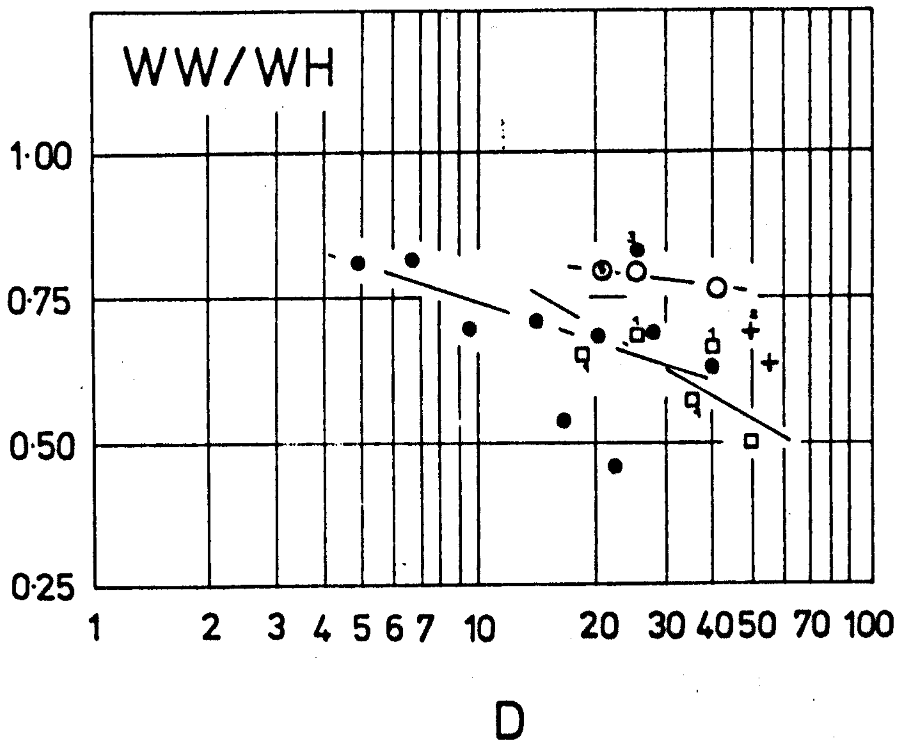


Textfig. 5.32a *Cymaclymenia striata grp.*



Cymaclymenia striata grp. Textfig. 5.32b





Textfig. 5.33 Cymaclymenia

Cymaclymenia semistriata (Münster 1832)

A, growth-line, B, constriction and C, suture at D=18.1, U=7.1, WW=5.5; D, whorl section at WW=5.7, WH=7.4, all x3.66: SM H10416, Münster Collection, Schübelhammer, Oberfranken.

Cymaclymenia sp. b

E, growth-line (reversed) at WW=9.5, WH=15; F, suture and G, constriction (both reversed) at D=32.8, WW=11, WH=17, all x3.66; H, (unlettered on the figure), cross-section at D=43, x2.5: SM H10406, Münster Collection, Schübelhammer, Oberfranken.

Cymaclymenia aff. barbarae (Loewinson-Lessing 1892)

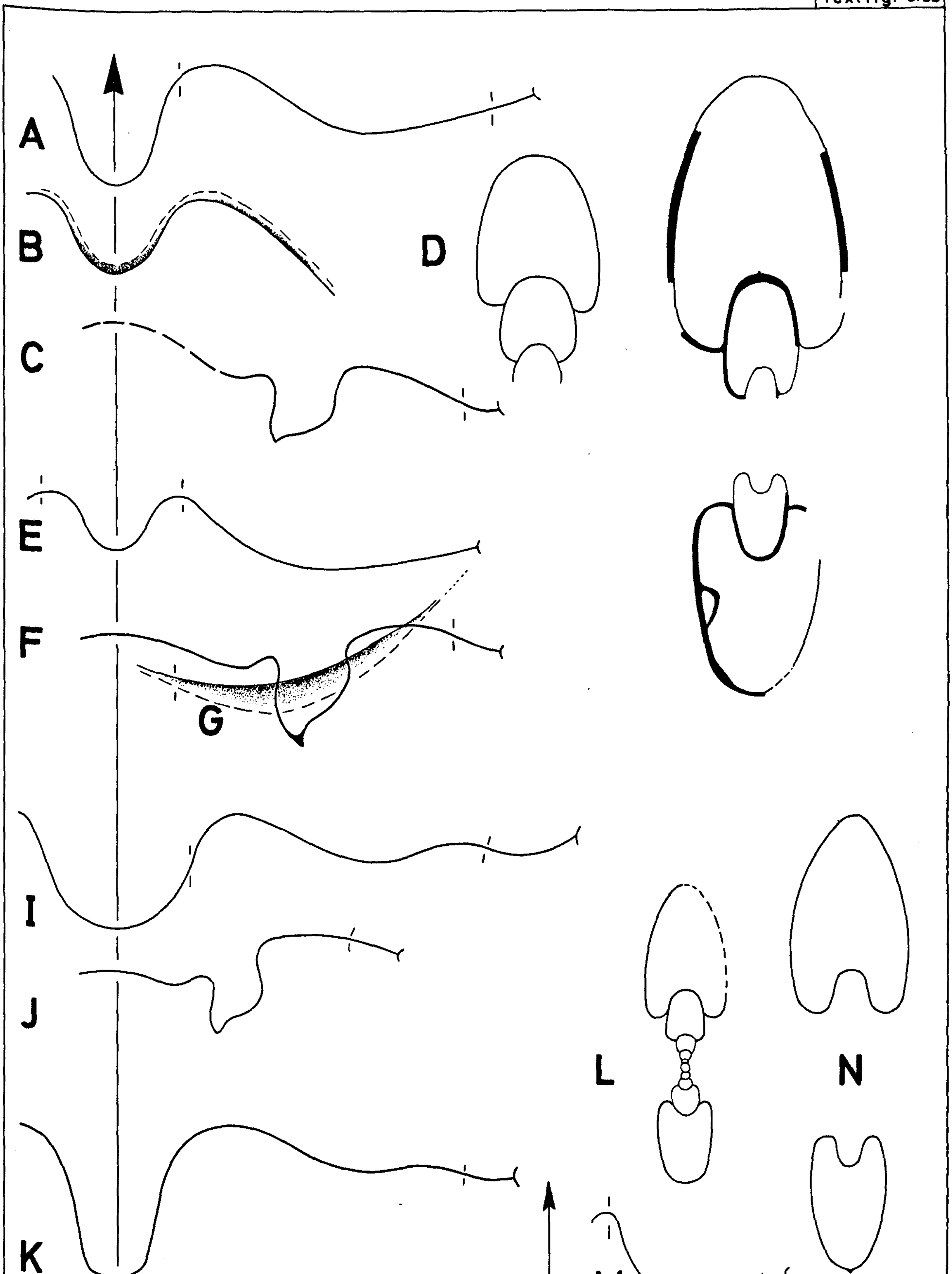
I, growth-line at WH=14.8, and J, suture, at WH ca 13.5, x3.33: KW 2084, Reigern Quarry, Sauerland.

Cymaclymenia serpentina (Schmidt 1924)

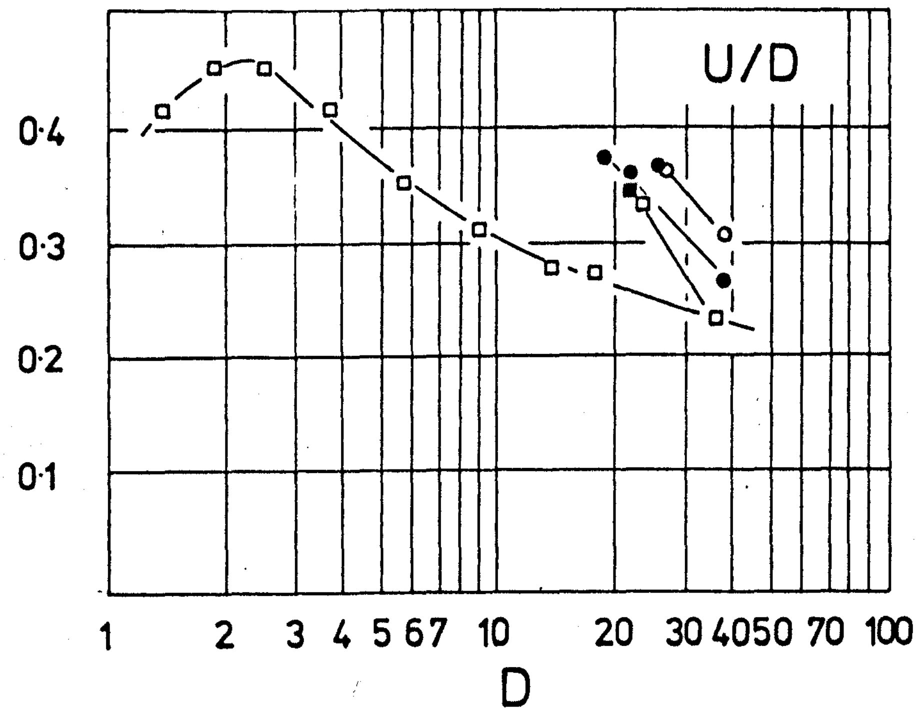
K, growth-line at WW=8.9, WH=11.5, x5.33: UEN, ?Münster Collection, ?Schübelhammer.

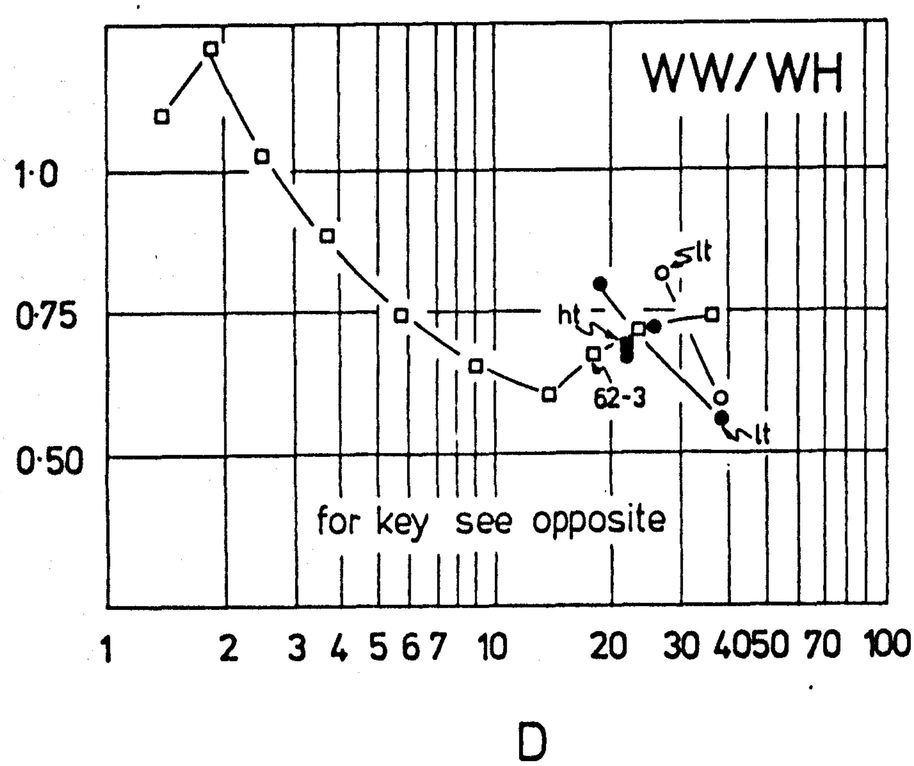
Cymaclymenia sp. a

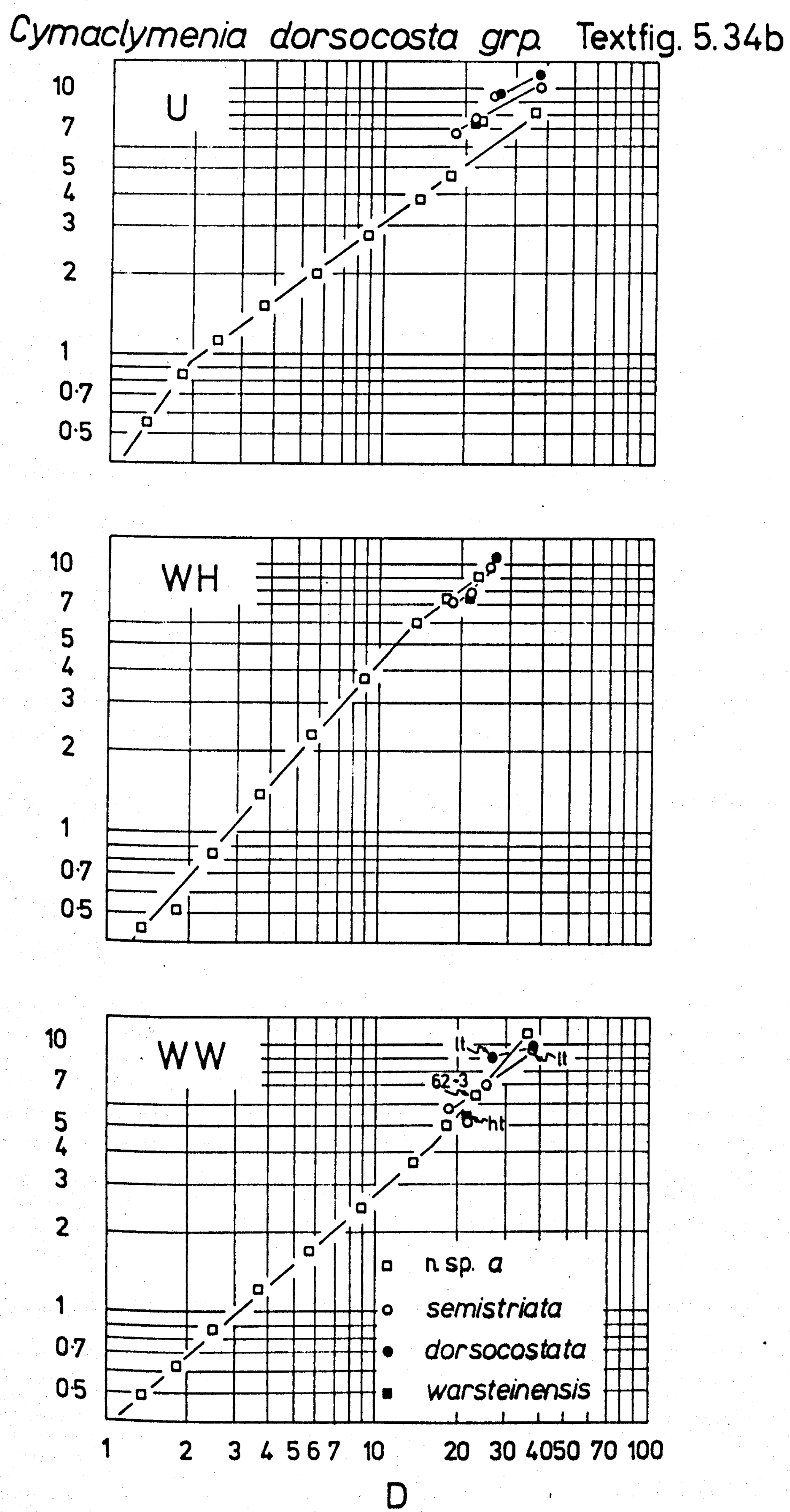
L, cross-section at D=8.95, x5.8; M, growth-line at D=14.2, WH=7.5, x4: HU P82.5, Effenberg, Sauerland. N, whorl section at D=24, x3.33: SM H7534, Münster Collection, Schübelhammer, Oberfranken.


A
B
C
D
E
F
G
I
J
K
L
M
N

Textfig. 5.34a *Cymaclymenia dorsocostata grp.*







Cymaclymenia dorsocosta grp. Textfig. 5.34b
U
WH
WW
10
7
5
4
3
2
1
0·7
0·5
lt
lt
62-3
ht
n. sp. a
semistriata
dorsocostata
warsteinensis
1 2 3 4 5 6 7 10 20 30 40 50 70 100
D

Plate 5.1

All illustrations are natural size unless otherwise indicated.

Hexaclymenia hexagona (Wedekind 1908)

Figs. 1,2, x3: Mbg; Kaske Collection, Enkeberg, Sauerland.

Figs. 3,4, x3: Mbg; Kaske Collection, Enkeberg, Sauerland.

Progonioclymenia (Progonioclymenia) aegoceras (Frech 1902)

Figs. 5,6, x2: Mbg; Kayser Collection, Grosser Pal, Carnic Alps.

Figs. 7,8, x2; 14, x5; 15, x10: Mbg 3130; Schwalm Collection, Braunau near Wildungen, Kellerwald. Figured by Schindewolf 1923a, pl. XVII, fig. 12, as Platyclymenia (?) acuticosta Braun.

Endosiphonites (Costaclymenia) binodosa (Münster 1832)

Figs. 9, x2; 10: MfN c429.7; Brügge Collection, Bed 26, Alte Heerstrasse, Schleiz. Figured by Brügge 1973, pl. 1, fig. 5, as Costaclymenia binodosa.

Endosiphonites (Costaclymenia) kiliani (Wedekind 1914)

Fig. 11; MfN c429.6; Brügge Collection, Bed 16, Alte Heerstrasse, Schleiz. Figured by Brügge 1973, pl. 2, fig. 1, as Costaclymenia binodosa.

Figs. 12,13: BM 81851; Münster Collection, Schübelhammer, Oberfranken.

Plate 5.1

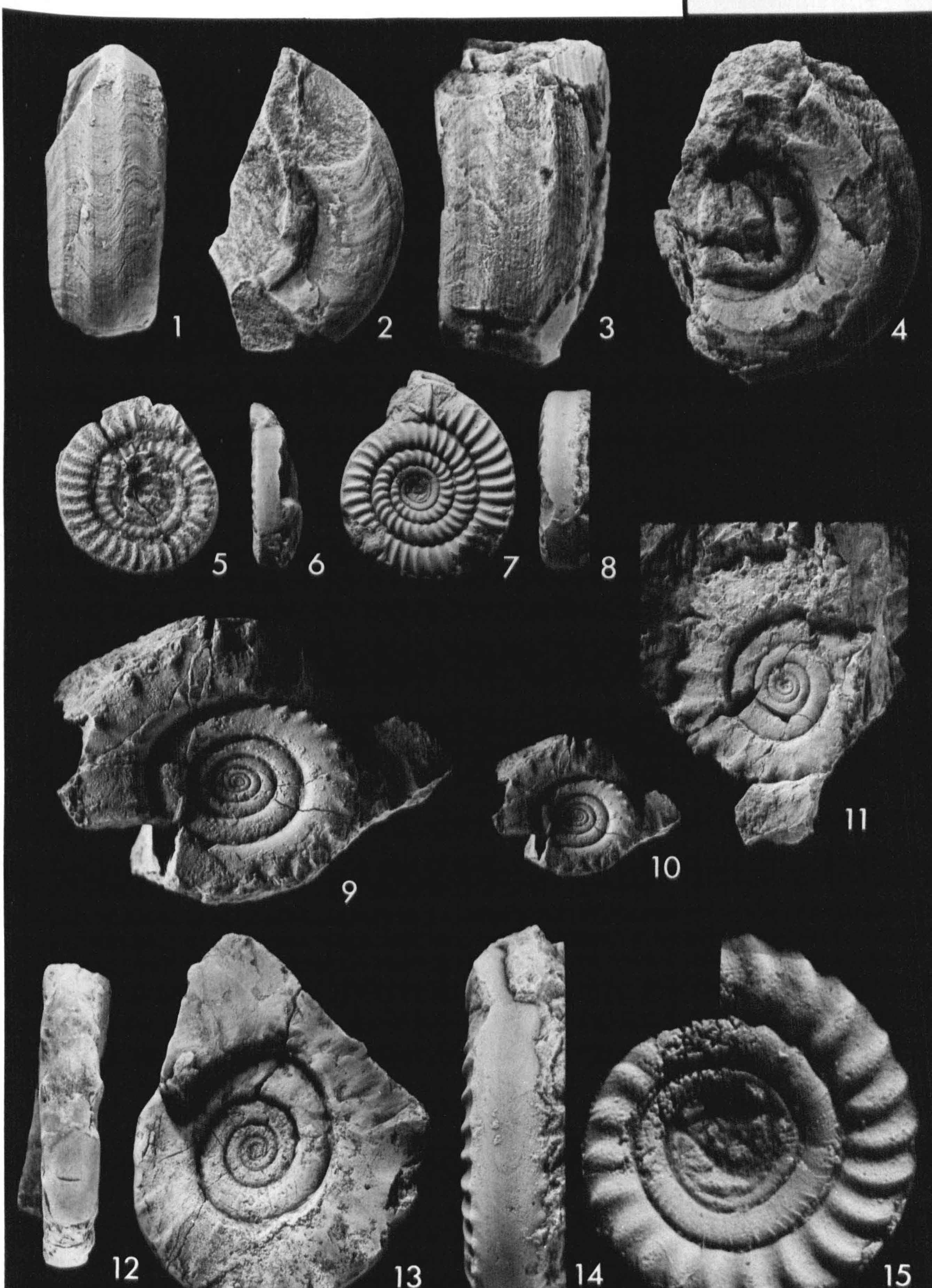


Plate 5.2

All illustrations are natural size unless otherwise indicated.

Endosiphonites (Costaclymenia) binodosa (Münster 1832)

Fig. 1: proposed neotype MfN; Krantz Collection, Schübelhammer, Oberfranken.

Endosiphonites (Costaclymenia) sp. indet.

Fig. 2: BSP AS VII 588; Münster Collection, Schübelhammer, Oberfranken. Figured by Gümbel 1863, pl. XIX, figs. 1a,b. The retrochoanitic septal necks can be seen extending backwards three-quarters of the distance between adjacent, slightly concave septa.

Endosiphonites (Costaclymenia) kiliani (Wedekind 1914)

Figs. 3,6,7: BSP AS VII 590; Münster Collection, Schübelhammer, Oberfranken. Figured by Münster 1839, pl. XII, figs. 3a-c, as Clymenia binodosa.

Figs. 4,5: SM H10385; Münster Collection, Schübelhammer, Oberfranken.

Figs. 8,9: BSP AS VII 587; Münster Collection, Schübelhammer, Oberfranken. Figured by Gümbel 1863, pl. XIX, figs. 1a-b, as Clymenia binodosa (photographs by M. R. House).

Endosiphonites (Endosiphonites) enodis (Schindewolf 1937a)

Figs. 10,11: holotype MfN; Schwalm Collection, Braunau near Wildungen, Kellerwald. Figured by Schmidt 1924, pl. 6, figs. 31a, as Costaclymenia Wysogorskii Frech.

Endosiphonites (Endosiphonites) muensteri Ansted 1838

Figs. 12,13: holotype SM H4010; Ansted Collection, Petherwin Beds, South Petherwin, Launceston, Cornwall. Figured by Ansted 1838, pl. VIII, figs. 1, 4?

Plate 5.2

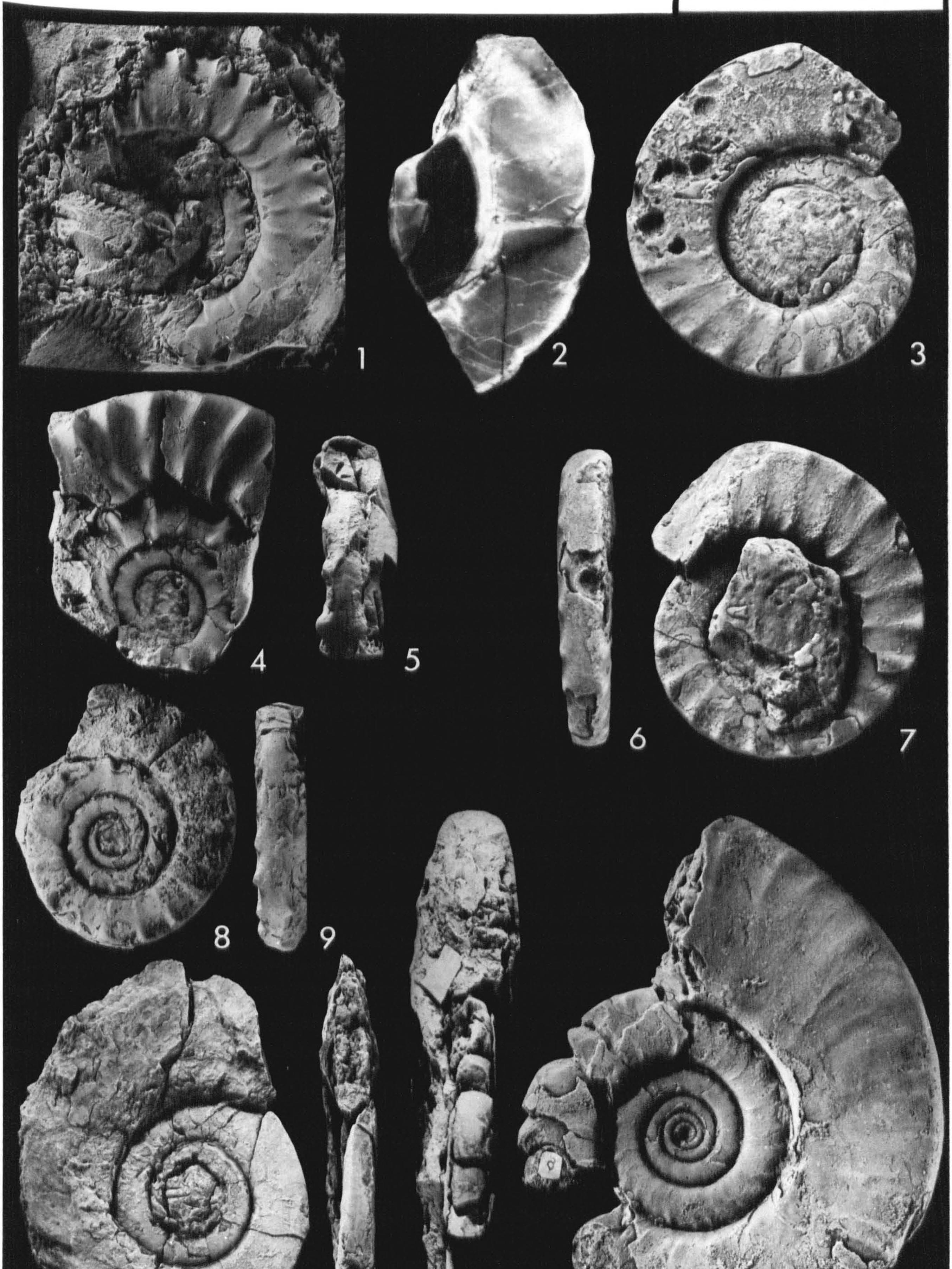


Plate 5.3

All illustrations are natural size unless otherwise indicated.

<u>Gonioclymenia</u> (<u>Gonioclymenia</u>) <u>speciosa</u> (Münster 1831)

Figs. 1, x½, 9, x1½. BSP AS VII 595; Münster Collection, Schübelhammer, Oberfranken. Figured by Münster 1839, pl. XVIII, fig. 6, as <u>G</u>. <u>speciosus</u>. A series of funnel-like structures can be seen on both figures. These are the contiguous rectrochoanitic septal necks and they seem to form a tube almost completely enclosing the siphuncle.

Figs. 3, 4, x¾: BSP AS VII 538; Münster Collection, Schübelhammer, Oberfranken. Figured by Gümbel 1863, pl. XIX, figs. 6a-c, but with inner whorls drawn in.

Figs. 7, 8, x0.66: proposed lectotype, BSP; Münster Collection, Schübelhammer, Oberfranken. Possibly the specimen figured by Münster 1832, pl. VI, figs. 1a-c.

<u>Gonioclymenia</u> (<u>Gonioclymenia</u>) <u>subcarinata</u> (Münster 1839)

Fig. 2: SM H10409a; Münster Collection, Schübelhammer, Oberfranken. Inner whorls show a spinose nodation on the ventro-lateral shoulder.

Figs. 5, 6, x¾; proposed lactotype, BSP AS VII 596; Münster Collection, Schübelhammer, Oberfranken. Figured by Münster 1839, pl. XVIII, figs. 1a-c.

Plate 5.3

Plate 5.4

All illustrations are natural size unless otherwise indicated.

Gonioclymenia (Gonioclymenia) speciosa (Münster 1831)

Figs. 1, 8: BSP AS VII 538; Münster Collection, Schübelhammer, Oberfranken. Fig. 1 is a view of the reverse of the specimen in Pl. 5.3, Fig. 3, showing the poor nature of the preservation of the sutures, effected by weathering, filing and polishing. Fig. 8 shows the whorl cross-section, which is more compressed than in Pl. 5.3, Fig. 4.

Gonioclymenia (Gonioclymenia) spp. indet.

Fig. 2, x6: SM H10387; Münster Collection, Schübelhammer, Oberfranken. The ornament of the early whorls can be seen, consisting of large spines projecting from the ventro-lateral shoulder.

Fig. 3, x2: BSP AS VII 519; Münster Collection, Schübelhammer, Oberfranken. Figured by Gümbel 1863, pl. XIX, fig. 8, as Clymenia cottai Münster.

Gonioclymenia (Gonioclymenia) aff. subcarinata (Münster 1839)

Fig. 4, x2: BM 81839b; Münster Collection, Schübelhammer, Oberfranken. This specimen shows the shallow nature of the ventro-lateral lobe.

Gonioclymenia (Gonioclymenia) subcarinata (Münster 1839)

Figs. 5, 6, 7; RE 551.734.5 A256; Torley Collection, Hövel, Sauerland. Figured by Wedekind 1914, pl. VI, fig. 6; this specimen is proposed as the lectotype of Gonioclymenia (Gonioclymenia) subcarinata praematura Wedekind 1914.

Plate 5.4

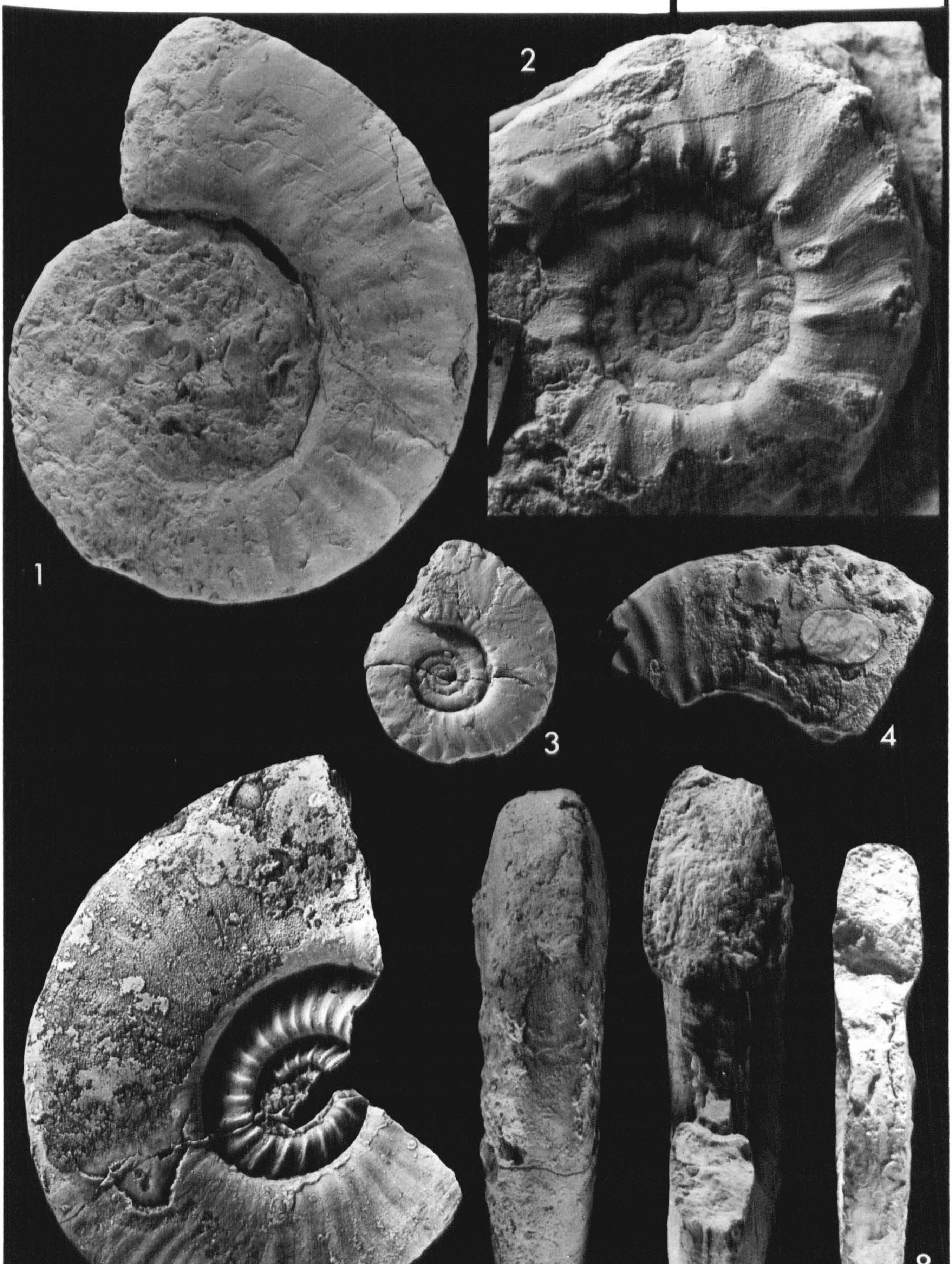


Plate 5.5

All illustrations are natural size unless otherwise indicated.

Gonioclymenia (Kalloclymenia) pessoides (von Buch 1838)

Figs. 1-3, x1½: lectotype, MfN, Dzikowiec, Dolny Śląsk. Figured by von Buch 1838, taf. - Fig. I, 1-3 and Lange 1929, pl. 2, fig. 19.

Gonioclymenia (Kalloclymenia) crassa (Wedekind 1914)

Figs. 4-6; 7, x1½; 12, x5: proposed lectotype, RE 551. 734.5 A255; Hövel, Sauerland. Figure 7 shows the deep narrow pointed dorsal lobe and in Figure 12 can be seen the parabolic nodes on the ventrad part of the flank, diagnostic of the subgenus Kalloclymenia. Each nodes marks the end of a distinct period of continuous growth, indicated by the different alignment of growth-lines on either side of the former apertures. This specimen was figured by Wedekind (1914, pl. VI, fig. 3)

Gonioclymenia (Kalloclymenia) uhligi (Frech 1902)

Figs. 9-11: holotype MfN c550; Dzikowiec, Dolny Śląsk. figured by Frech 1902, pl. II(I), fig. 1. The holotype is poorly preserved and thus difficult to compare with other species of Kalloclymenia.

Gonioclymenia (Kalloclymenia) subarmata (Münster 1832)

Figs. 8, x4; 13, 14 x¾: lectotype, BSP AS VII 537; Münster Collection, Schübelhammer, Oberfranken. Parabolic nodes can be seen on the inner whorls. Figure 8 was figured by Münster 1832, pl. VI, figs. 2a-c. (Photographs for Figs. 13, 14 by M. R. House).

Plate 5.5

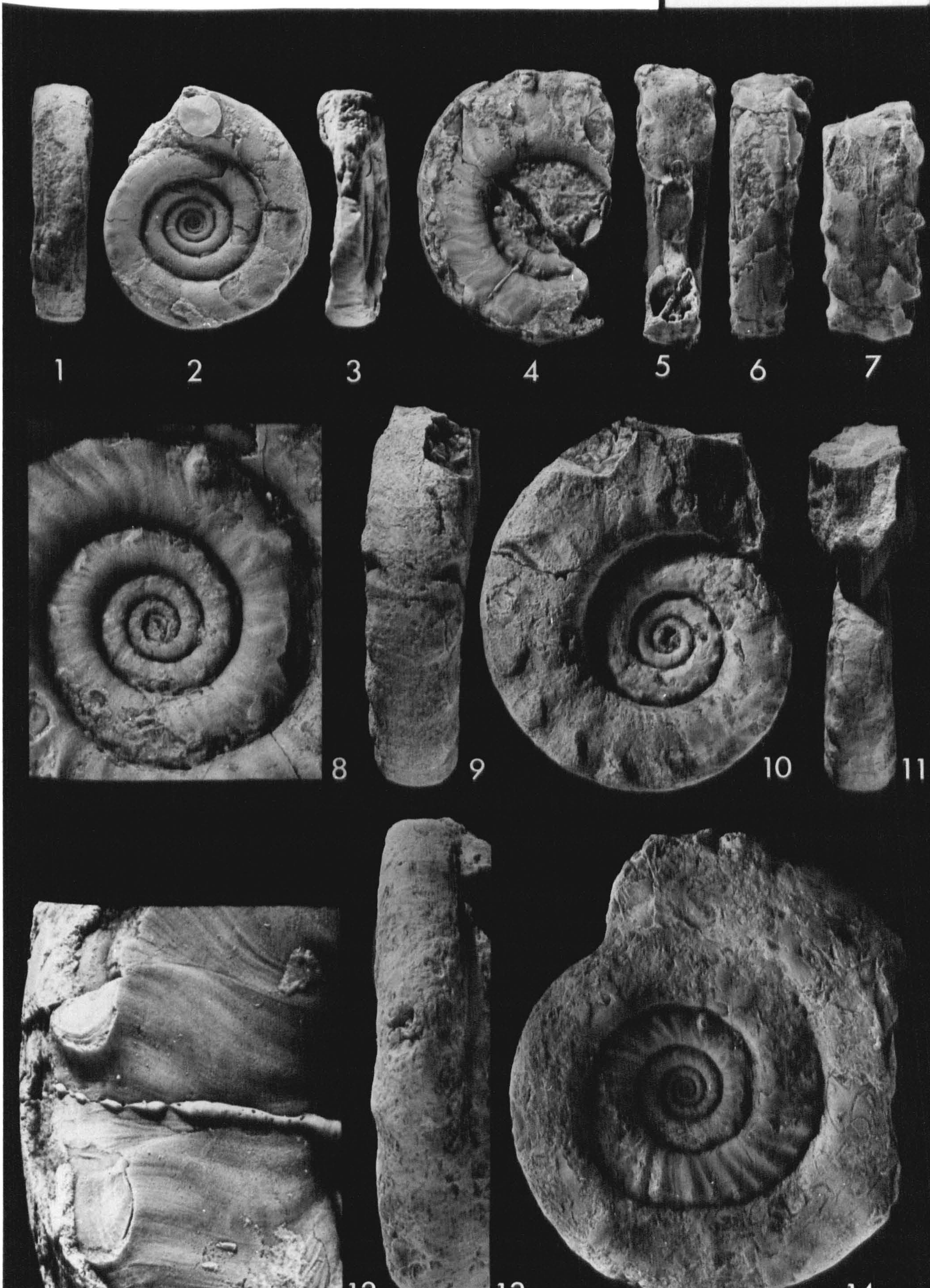


Plate 5.6

All illustrations are natural size unless otherwise indicated.

Gonioclymenia (Kalloclymenia) ?subarmata (Münster 1832)

Figs. 1, 2: BSP AS VII 593; Münster Collection, Gattendorf, Oberfranken. Figured by Münster, 1842, pl. XII, fig. 4. (Photographs by M. R. House).

Fig. 3: SM H4015; Barnstaple. Holotype of Goniatites vinctus Sowerby 1840, figured by Sowerby in Sedgwick and Murchison 1840, pl. LIV, fig. 18.

Fig. 4, x1½: SM H10314; Münster Collection, Schübelhammer, Oberfranken. Labelled as Goniatites angustus Münster, and proposed as the lectotype.

Figs. 5, 6, x1½: SM H10407; Münster Collection, Schübelhammer, Oberfranken. Labelled as G. spurius Münster, and proposed as the lectotype.

Gonioclymenia (Kalloclymenia) insignis (Phillips 1841)

Figs. 7, x3; 8, 10; 9, x2: holotype, GSM 7083; Petherwin Beds, Landlake limestone quarry, Launceston, Cornwall. Figured by Phillips 1841, pl. XLIX, fig. 228.

Plate 5.6

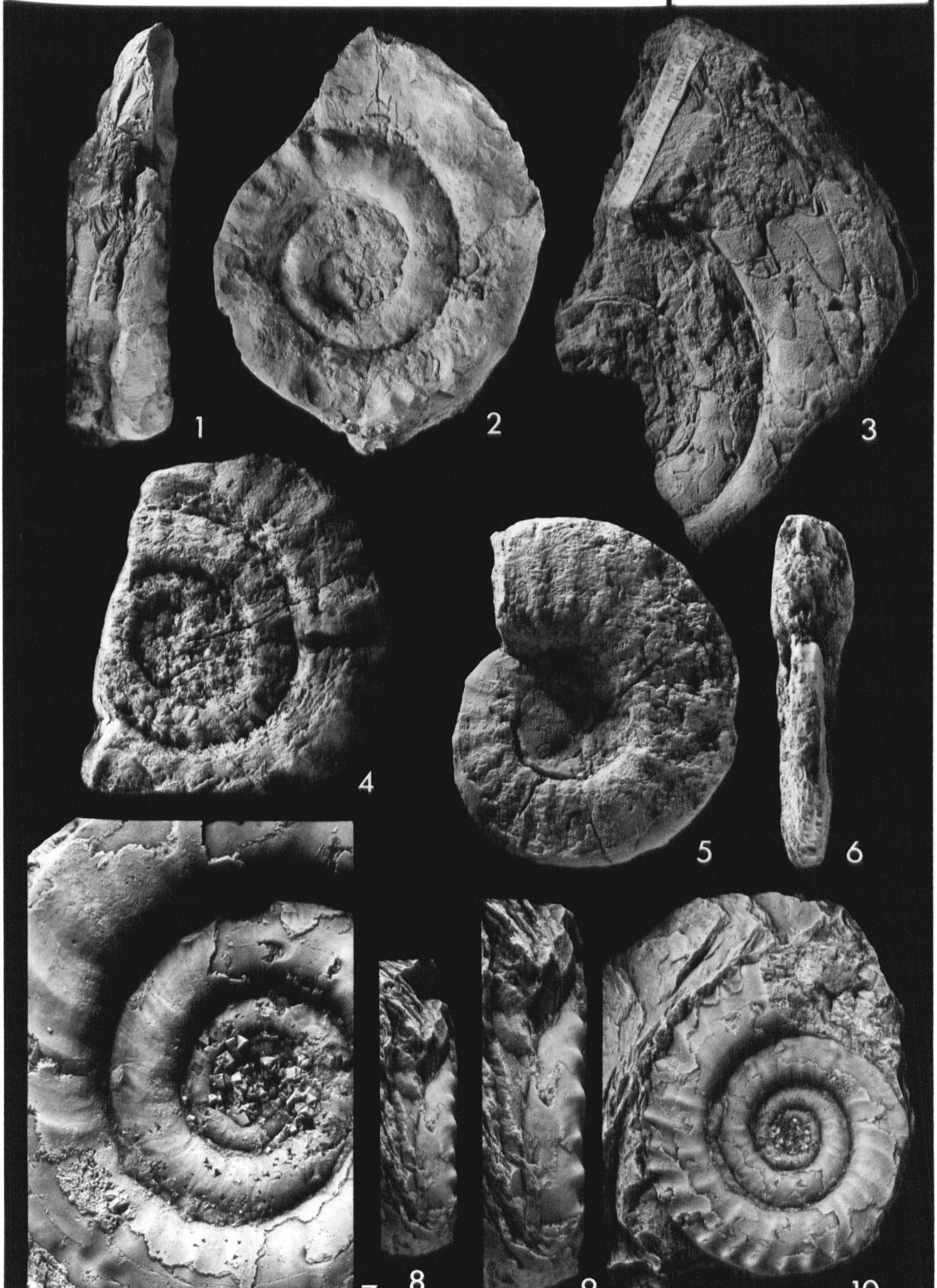


Plate 5.7

All illustrations are natural size unless otherwise indicated.

<u>Gonioclymenia</u> (<u>Kalloclymenia</u>) <u>subarmata</u> (Münster 1832)

Figs. 1, 2: lectotype, BSP AS VII 537; Münster Collection, Schübelhammer, Oberfranken. Considered to be the specimen on which Münster 1832, pl. VI, figs. 2a-c is based.

Figs. 4, 5: SM H10394; Münster Collection, Schübelhammer, Oberfranken. Specimen on which the cross-section Textfig. 5.9B is based.

<u>Gonioclymenia</u> (<u>Gonioclymenia</u>) <u>subcarinata</u> (Münster 1839)

Fig. 3: holotype, BSP AS VII 596; Münster Collection, Schübelhammer, Oberfranken. View of weathered side showing the suture with shallow adventive lobe (at three o'clock), (photograph by M. R. House).

Plate 5.7

Plate 5.8

All illustrations are natural size unless otherwise indicated.

Gonioclymenia (Subgen. Nov. B) wocklumensis (Lange 1929)

Figs. 1, 5, 6, x2: holotype MfN; Lange Collection, Burg, Balve, Sauerland. Figured by Lange 1929, pl. II, figs. 18,a.

Gonioclymenia (Subgen. Nov. B) frechi (Lange 1929)

Figs. 3, 4: holotype, MfN; Otto Collection, Dzikowiec, Dolny Slàşk. Note the small spines on the ventro-lateral shoulders of the inner whorls. Figured by Frech 1902, pl. II(I), figs. 14a,b.

Gonioclymenia (Subgen. Nov. B) biimpressa (von Buch 1838)

Figs. 7-9: holotype, MfN; von Buch Collection, Dzikowiec, Dolny Slask. Figured by von Buch 1838, taf. - fig. II, 1-3.

Gonioclymenia (Subgen. Nov. B) aff. wocklumensis (Lange 1929)

Fig. 10: SM H10373; Münster Collection, Schübelhammer, Oberfranken. Specimen on which Textfigs.5.9H,I are based.

Plate 5.8

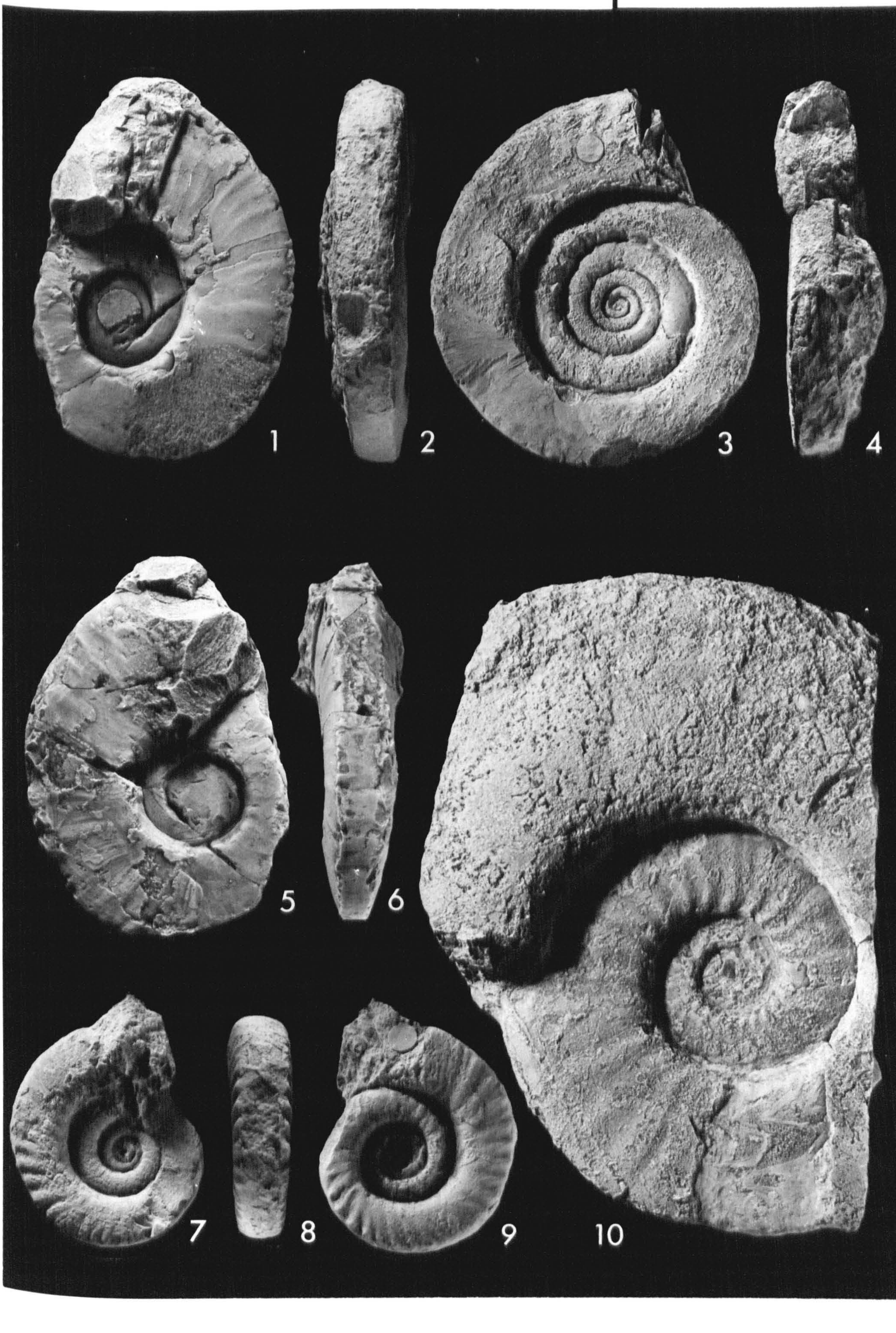


Plate 5.9

All illustrations are natural size unless otherwise indicated.

Sphenoclymenia intermedia (Münster 1832)

Figs. 1, 2: SM H10397; Münster Collection, Schübelhammer, Oberfranken. The apertural direction is to the right-hand side of Fig. 2.

Figs. 3-5, x¾: lectotype, BSP AS VII 586, Münster Collection, Schübelhammer, Oberfranken. Specimen figured by Gümbel 1863, pl. XXI, figs. 3a-c. (Photographs by M. R. House).

Gonioclymenia (Subgen. Nov. *A*) *brevispina* (Lange 1929)

Figs. 6, 7, x2; 8: MfN; Schindewolf Collection, Oberröding-hausen railway-cutting, Balve, Sauerland. Bed 11 of Schindewolf 1937a.

Figs. 9, 10, x2: proposed lectotype, MfN, Dzikowiec, Dolny Slàşk. Figured by Frech 1902, pl. II(I), fig. 3a, in combination with another specimen. Figure 10 is the same specimen as that illustrated in Figure 9, which is wetted to show the suture.

Plate 5.9

Plate 5.10

All illustrations are natural size unless otherwise indicated.

Gonioclymenia (?Gonioclymenia) sp.

Figs. 1, 2: BSP AS VII 591; Münster Collection, Schübelhammer, Oberfranken. Labelled as Cl. semicostata. This specimen differs from known species of Gonioclymenia (Gonioclymenia) by its denser ribbing, which continues over the only slightly grooved venter. It greatly resembles the specimen figured by Münster 1839, pl. XVI, figs. 2a-d as Clymenia semicostata, except that it has a ventral lobe.

Sellaclymenia sp.

Figs. 3; 4, x2: BSP AS VII 592; Münster Collection, Schübelhammer, Oberfranken. Figured by Gümbel 1863, pl. XIX, figs. 3a-c, as Münster's original of Cl. semicostata, which it clearly is not.

Sellaclymenia plana (Münster 1832)

Fig. 5: (GT 2041); Trost Collection, Dasberg, Balve, Sauerland.

Figs. 6, x1½; 7, x7; 10-12: lectotype, Fig. 10, MfN c601; Figs. 6, 7, 11, 12, BSP AS VII 594; Figure 6 shows the shape of the septa in sagittal section, and the siphuncle and septal necks, Figure 7 the early suture, and Figure 10 is the external mould of the specimen in Figure 12.

Figs. 8, 9: BSP AS VII 589; Münster Collection, Schübelhammer, Oberfranken. Figured by Münster 1839, pl. XVI, figs. 2a-c. Proposed as the lectotype of Cl. angulosa Münster 1839.

Plate 5.10

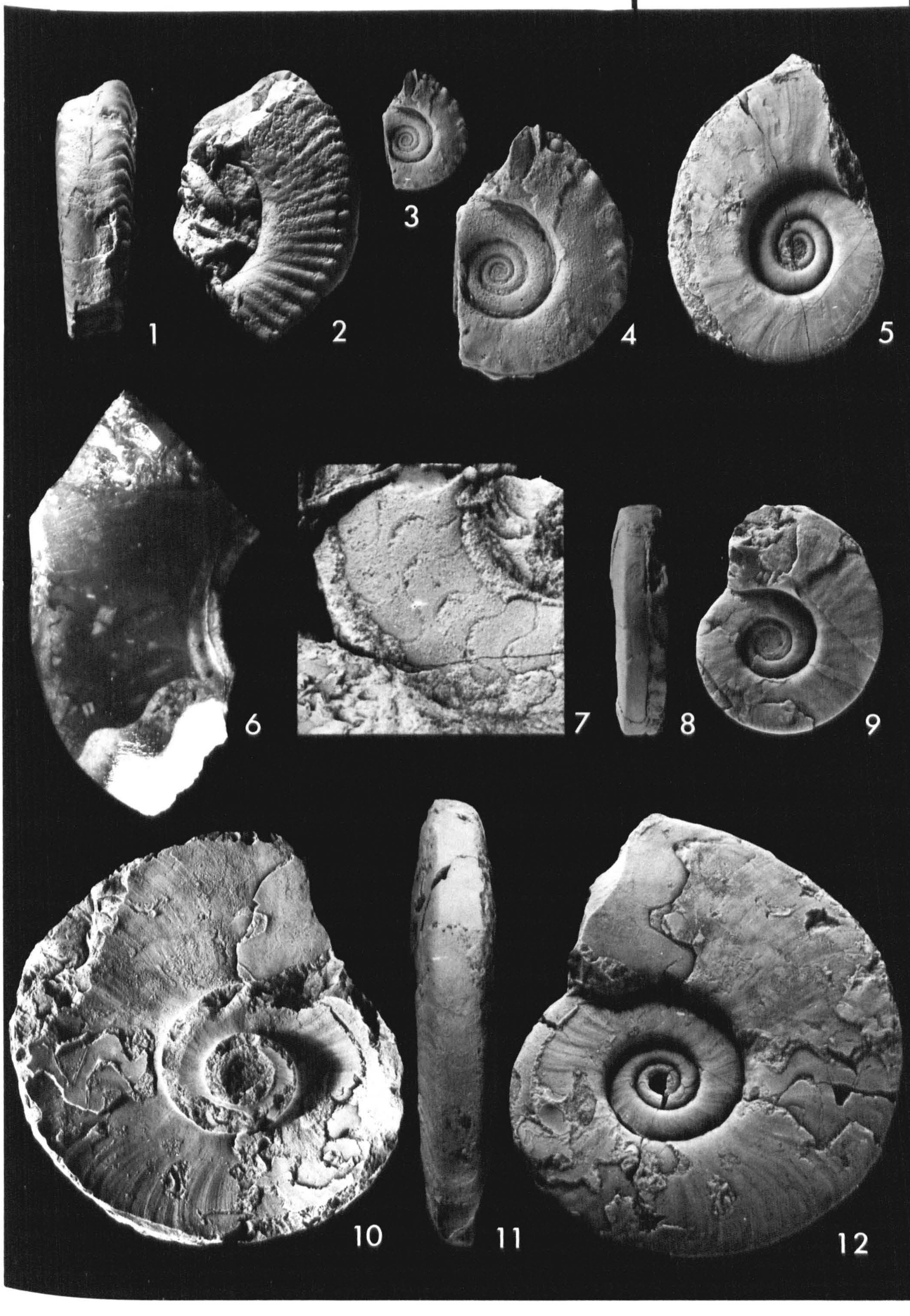


Plate 5.11

All illustrations are natural size unless otherwise indicated.

Biloclymenia sp.

Fig. 1: MfN; Schindewolf Collection, Beil, Balve.

Figs. 3, 4, x1½: MfN; Schindewolf Collection, Enkeberg (Marsberg). Figured by Schindewolf 1937a, pl. I, fig. 10.

Figs. 7-9; 10, x4: KW 2091; Wunderlich Collection, Langenholthausen, Balve. Figure 10 shows the wrinkle-layer on the venter of the preceding whorl, sealing over the pedicle valve of a disciniscid brachiopod and the tests of cemented Foraminifera.

Biloclymenia bilobata (Münster 1839)

Figs. 2, x4; 5, 6, x5: BSP AS VII 524; Münster Collection, Schübelhammer, Oberfranken.

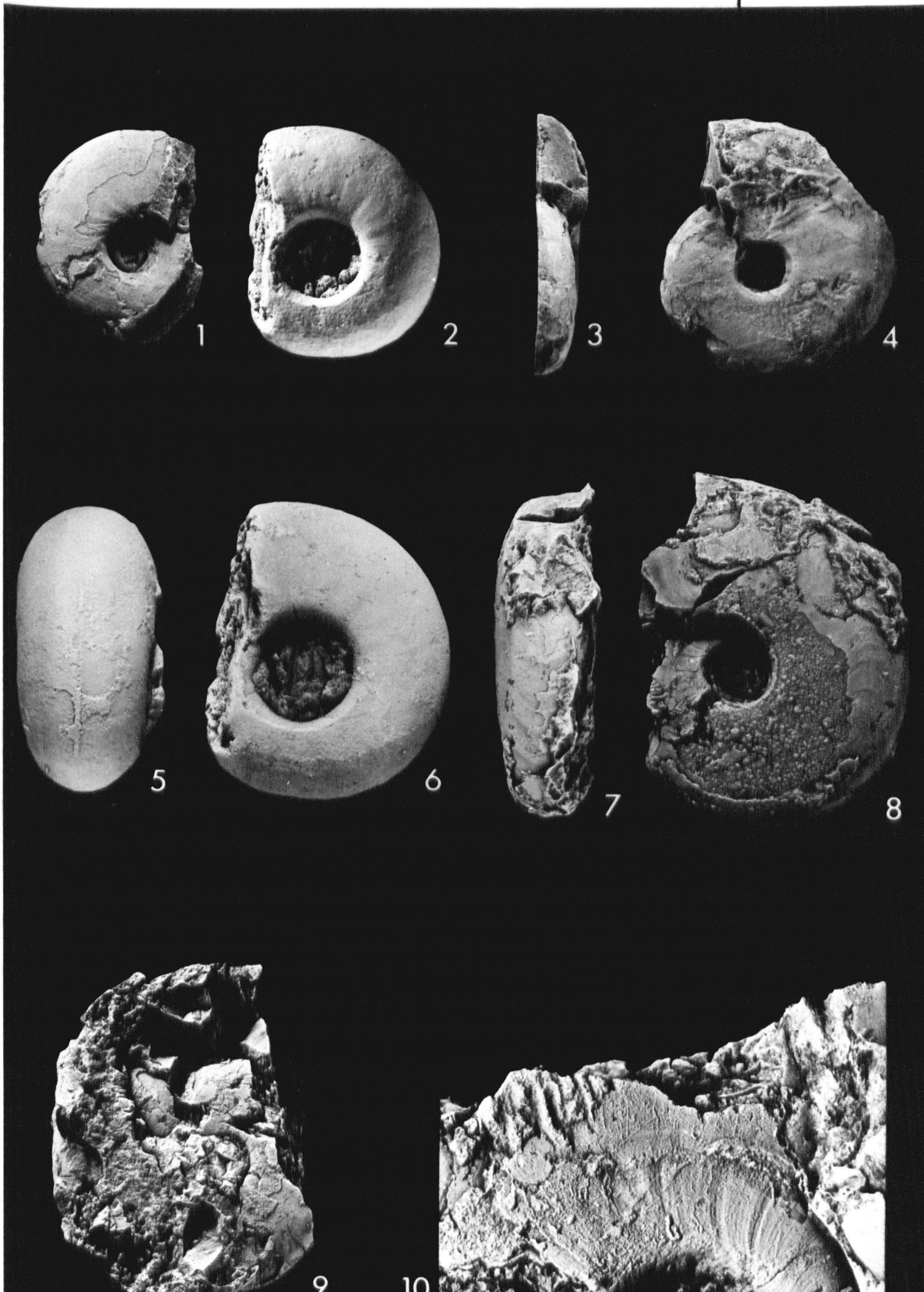

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Plate 5.12

All illustrations are natural size unless otherwise indicated.

Platyclymenia (_Platyclymenia_) _clarkei_ Schindewolf 1923a

Figs. 1,2, x2: lectotype, Mbg 3128; Schindewolf Collection, Bed 14, Kirch-Gattendorf, Oberfranken. Figured by Schindewolf (1923a, pl. XVII, fig. 10).

Platyclymenia (_Platyclymenia_) _annulata_ (Münster 1832)

Figs. 3,4, x2: Mbg 3125; Schindewolf Collection, Bed 14, Kirch-Gattendorf, Oberfranken. Figured by Schindewolf (1923a, pl. XVII, fig. 7).

Fig. 5, x2: Mbg; Schindewolf Collection, Bed 14, Kirch-Gattendorf, Oberfranken.

Fig. 8, x2: Mbg; Schindewolf Collection, Bed 14, Kirch-Gattendorf, Oberfranken.

Platyclymenia (_Platyclymenia_) _richteri_ (Wedekind 1914)

Fig. 6: SMM; Brakensiek Collection, Beil, Balve. Figured by Wedekind 1914, pl. III, fig. 1a, (photograph by D. Korn).

Figs. 7, x4; 9-11, x2; 12, x6: Mbg 3126; Langenaubach. Some of the ribs appear to intersect the growth-lines over the ventro-lateral shoulder, and therefore are transitional between _Platyclymenia_ and _Trigonoclymenia_-type ribbing.

PLATE 5.12

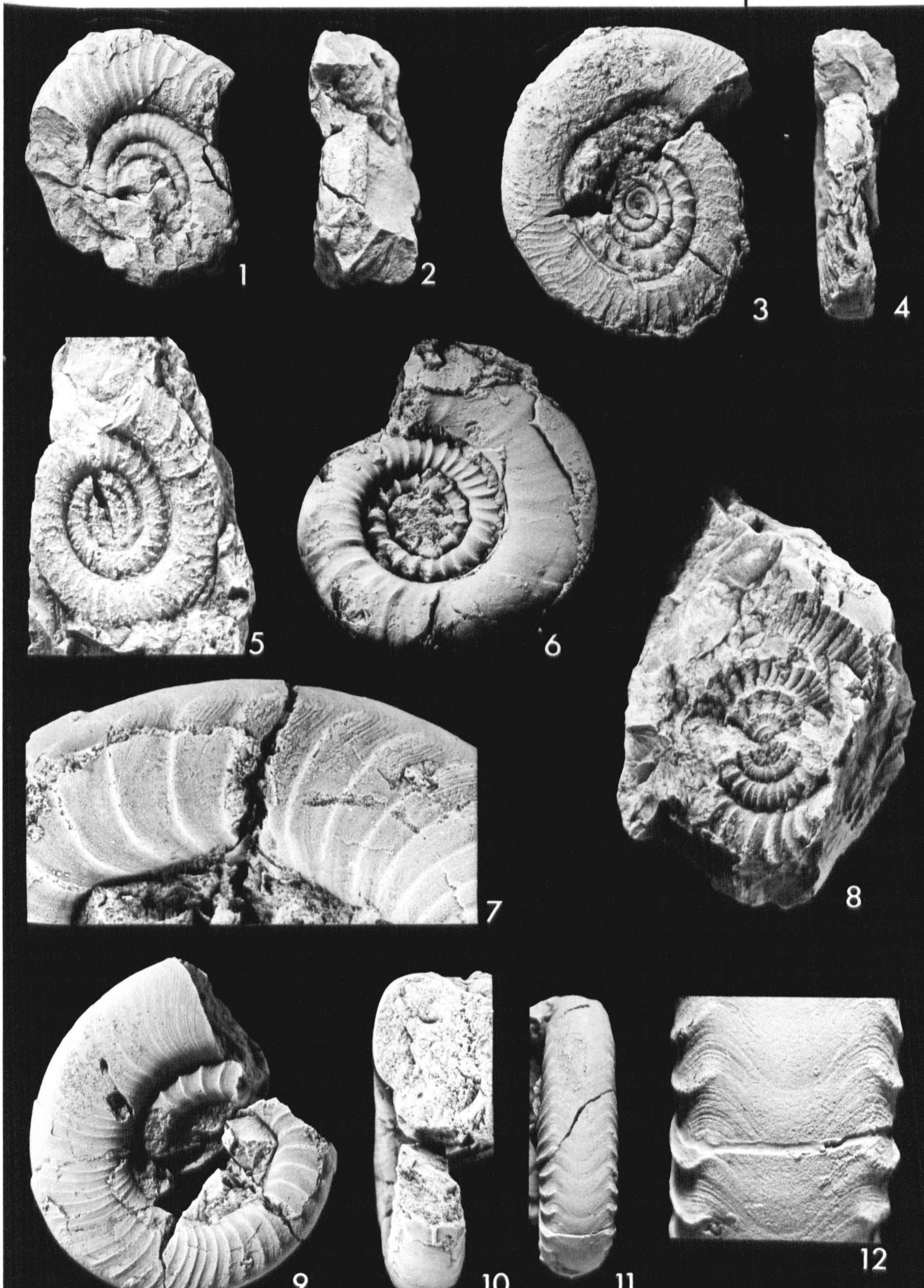

Plate 5.13

All illustrations are natural size unless otherwise indicated.

Platyclymenia (Platyclymenia) richteri Wedekind 1914

Figs. 1,12,x4; 3,4,5,8, x2; HU P82.3; 1 shows the wrinkle-layer concordant with growth-lines, and the string-like keel over the venter; 12 shows the periodic prominent ribs of the inner whorls, which cut across the intermediate growth-lines. *

Fig. 2, x2: HU P82.6; Wäschholz, Oberfranken.

Fig. 10: MfN; ?Münster Collection, Schübelhammer, Oberfranken.

Platyclymenia (Platyclymenia) quenstedti Wedekind 1914

Figs. 6,7, x1½: Mbg 3153; Bed 14, Kirch-Gattendorf, Oberfranken, ?figured by Schindewolf 1923a, textfig. 19a.

Platyclymenia (Platyclymenia) nodosa (Gümbel 1863)

Figs. 9,11: BSP AS VII 600; proposed lectotype. Figured by Gümbel 1863, pl. XVIII, 11a,b.

* See p 503 and Textfig. 7.8 for the collecting locality of this specimen.

PLATE 5.13

Plate 5.14

All illustrations are natural size unless otherwise indicated.

Platyclymenia (Platyclymenia) quenstedti Wedekind 1914

Figs. 1,2, x2; 5, x10; 6,7, x3: RE 551 734.5 A150/1, Beil, Balve.

Figs. 3,4, x2: MfN; Schindewolf Collection, Hauern, Wildungen.

Notice the ventral band on the venter. This species may be an antecedent of Aktuboclymenia and the Clymeniidae.

PLATE 5.14

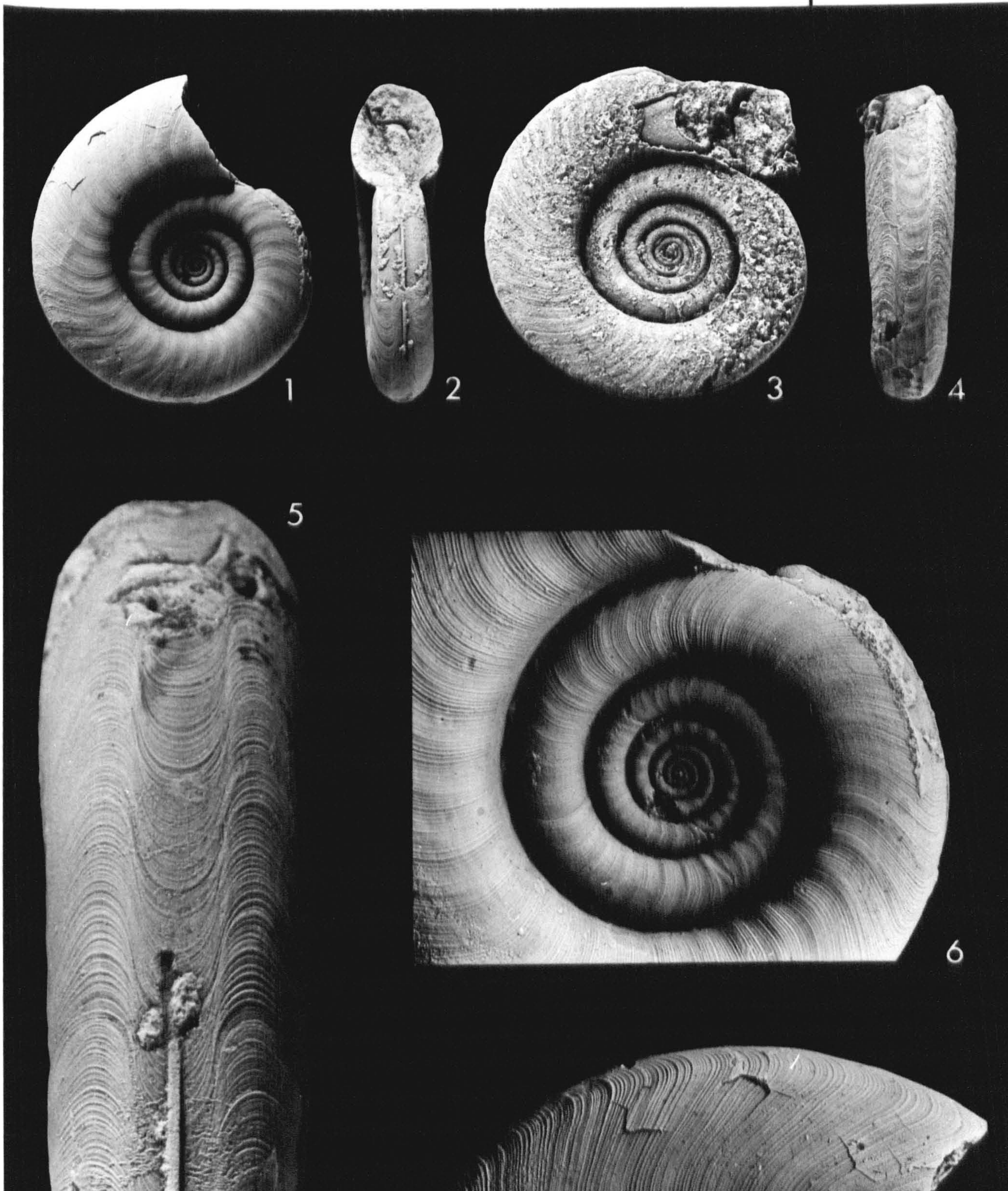

Plate 5.15

All illustrations are natural size unless otherwise indicated.

<u>Platyclymenia</u> (<u>Platyclymenia</u>) <u>subnautilina</u> (Sandberger 1855)

Figs. 1,9,10, x1½: Wsb.

Figs. 2,3, x1½: Wsb.

Figs. 4,8, x1½: Sandberger Collection, Kirschhofen, Weilburg. Parts of the specimens in Figs. 8-10 make up Sandberger 1855, pl. 1, figs. 1a-f. Figs. 4,8 are proposed as the lectotype and syntype, respectively.

<u>Platyclymenia</u> (<u>Platyclymenia</u>) ?<u>annulata</u> (Münster 1832)

Fig. 5, x2: Mbg; Schindewolf Collection, Bed 14, Kirch-Gattendorf, Oberfranken. Labelled as <u>Plat</u>. <u>annulata densicosta</u>.

<u>Platyclymenia</u> (<u>Platyclymenia</u>) sp. (Schindewolf 1923a)

Figs. 6,7, x2: BSP ii 122; Glass Collection, Kirch-Gattendorf. Figured by Schindewolf 1923a, pl. XVII, figs. 13a,b, as <u>Platyclymenia</u> <u>denckmanni</u>, and proposed here as the lectotype.

PLATE 5.15

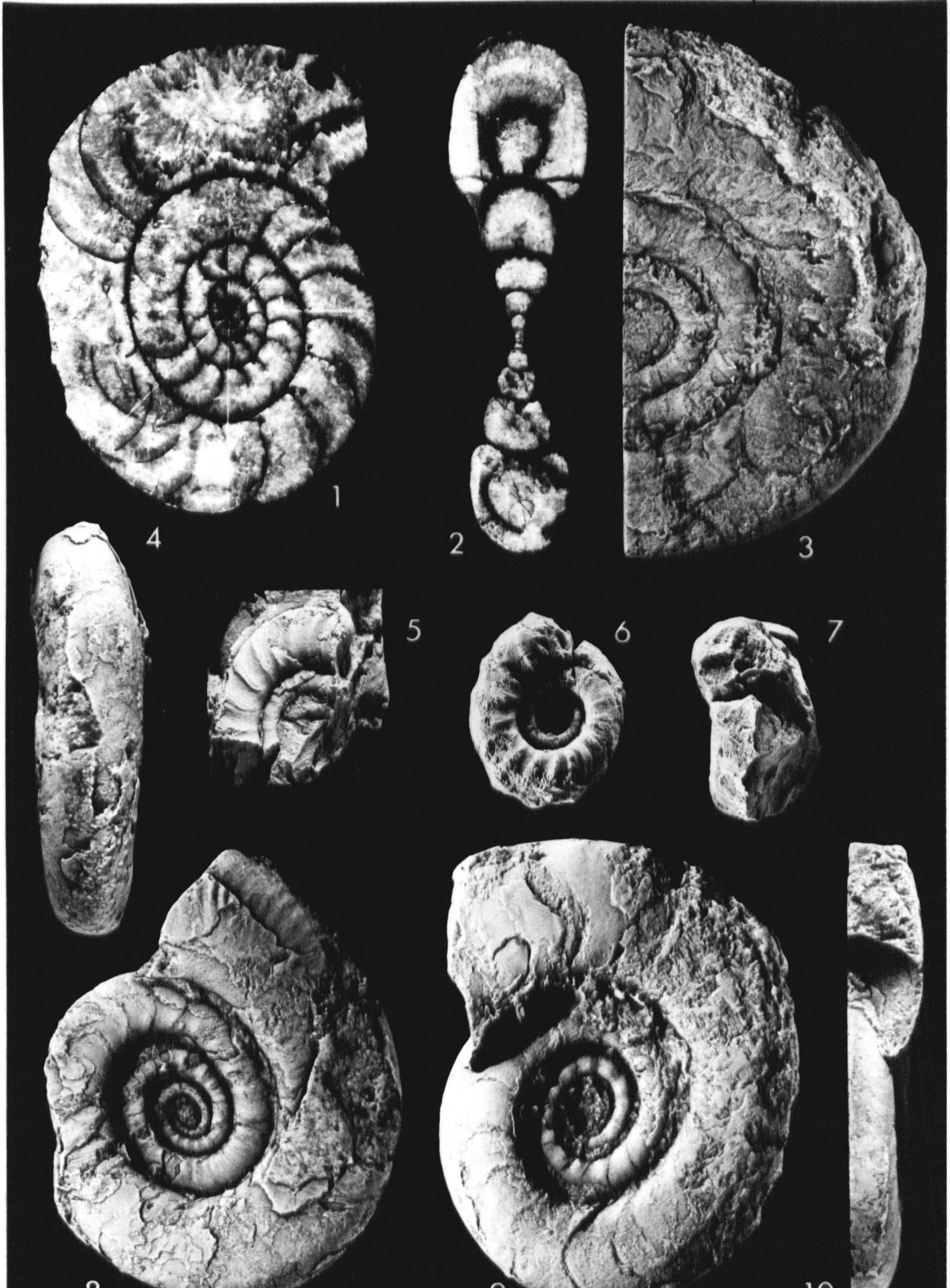

Plate 5.16

All illustrations are natural size unless otherwise indicated.

Platyclymenia (Platyclymenia) sp.

Fig. 1, x2: Mbg; Schindewolf Collection, Kirch-Gattendorf, Oberfranken. Holotype of Plat. walcotti var. raricosta Schindewolf 1923a.

Platyclymenia (Pleuroclymenia) crassissima Schindewolf 1955

Figs. 2,3,10, x2: holotype Mbg 3154; ?Schindewolf Collection, Kirschhofen, Weilburg.

Platyclymenia (Platyclymenia) prorsostriata Schindewolf 1923a

Fig. 4, x2: Mbg 3127; Schindewolf Collection, Bed 11, Kirch-Gattendorf, Oberfranken. Proposed as the lectotype.

Platyclymenia pattisoni (M'Coy 1851)

Figs. 5,6, x2: holotype SM H990; lower Petherwin Beds, Landlake Quarry, Launceston. Figured by M'Coy 1851, pl. IIA, fig. 11.

?Stenoclymenia valida (Phillips 1841)

Figs. 7,8, x2: holotype, GSM 7176; lower Petherwin Beds, Landlake Quarry, Launceston. Figured by Phillips 1841, pl. LIV, fig. 245.

Platyclymenia (Platyclymenia) valida sensu auctt.

Fig. 9, x2: MfN; Müller Collection, Bed 1, Alte Heerstrasse, Schleiz. Figured by Müller 1956, pl. 2, fig. 20.

PLATE 5.16

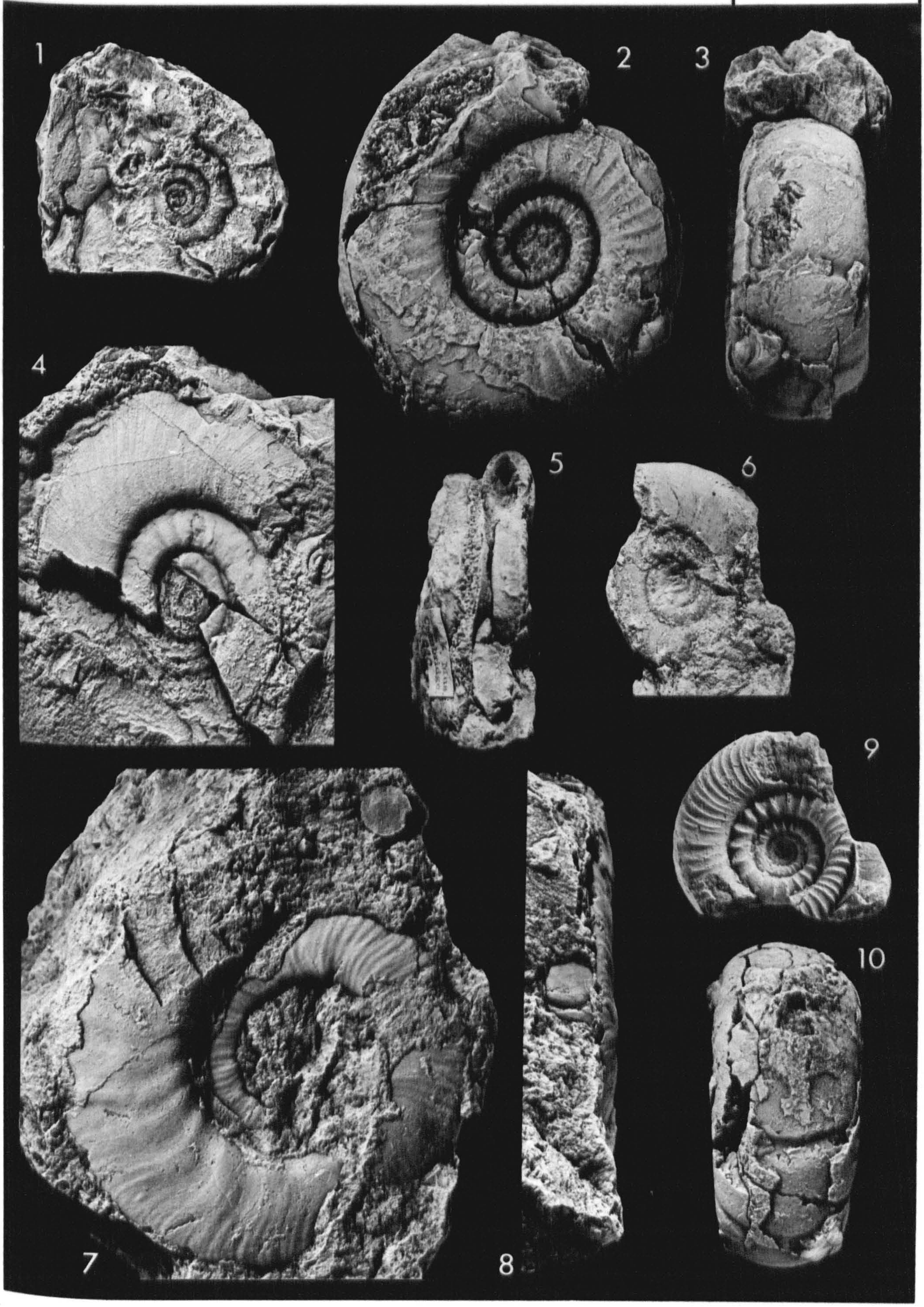

Plate 5.17

All illustrations are natural size unless otherwise indicated.

Platyclymenia (Trigonoclymenia) cf. barrandei (Wedekind 1914)

Fig. 1, x2: MfN; Schindewolf Collection, Hauern, Wildungen.

Platyclymenia (Trigonoclymenia) spinosa (Münster 1842)

Figs. 2,3, x1½: proposed lectotype, BSP AS VII 598; Münster Collection, Schübelhammer, Oberfranken. Figured by Münster 1842, pl. XI, figs. 15a,b.

Figs. 4,7, x6: BSP AS VII 522; Münster Collection, Schübelhammer, Oberfranken.

Figs. 5,6, x4: BSP AS VII 521; Münster Collection, Schübelhammer, Oberfranken.

Fig. 8, x2: KW 2064; Wunderlich Collection, Schübelhammer, Oberfranken.

PLATE 5.17

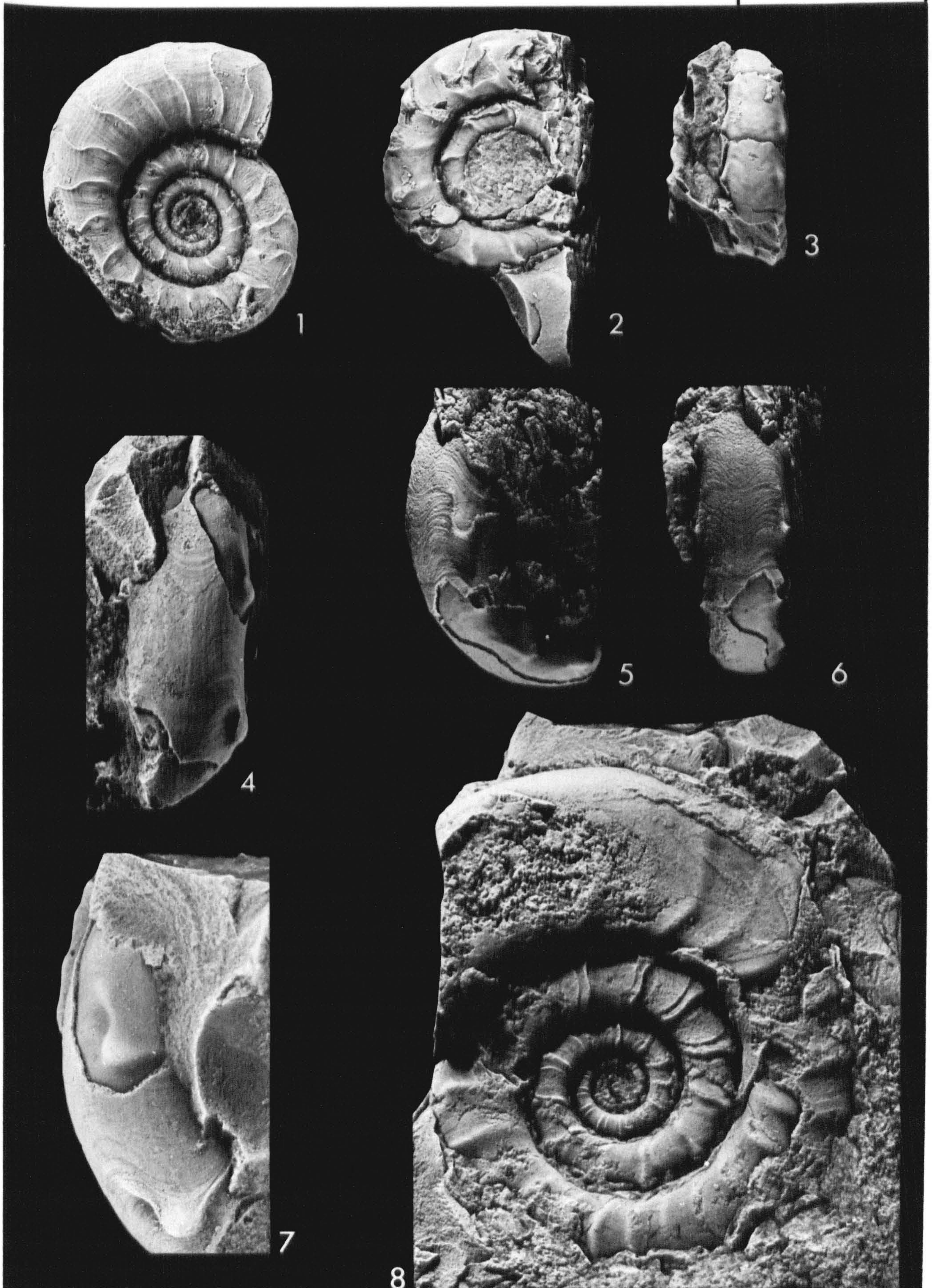

Plate 5.18

All illustrations are natural size unless otherwise indicated.

Clymenia cingulata Gümbel 1863

Fig. 1, x1½: MfN (ex Mbg); Braunau. Figured by Schindewolf 1923a, pl. XVIII, fig. 5.

Clymenia spiratissima (Schindewolf 1923a)

Fig. 2, x2: MfN; ?Münster Collection, Schübelhammer, Oberfranken.

Figs. 3, x3; 4, x11: UEN; ?Münster Collection, Schübelhammer, Oberfranken.

Clymenia laevigata (Münster 1831)

Figs. 5,6: BSP; Münster Collection, Schübelhammer, Oberfranken. ?Figured by Gümbel 1863, pl. XVI, figs. 6a. Labelled as *Cl. semiplicata*.

Figs. 7,8: proposed lectotype SM H10366; Münster Collection, Schübelhammer, Oberfranken.

Figs. 9,10: BSP AS VII 601; Münster Collection, Schübelhammer, Oberfranken. Figured by Gümbel 1863, pl. XVI, figs. 7a-c, as *Cl. laevigata* var. *elliptica*.

Figs. 11,12: BSP AS VII 603; Münster Collection, Schübelhammer, Oberfranken. Figured by Münster 1832, pl. 1, figs. 1d-f.

Figs. 13,14, x0.75: BSP AS VII 605; Münster Collection, Schübelhammer, Oberfranken. (Photographs by M. R. House).

PLATE 5.18

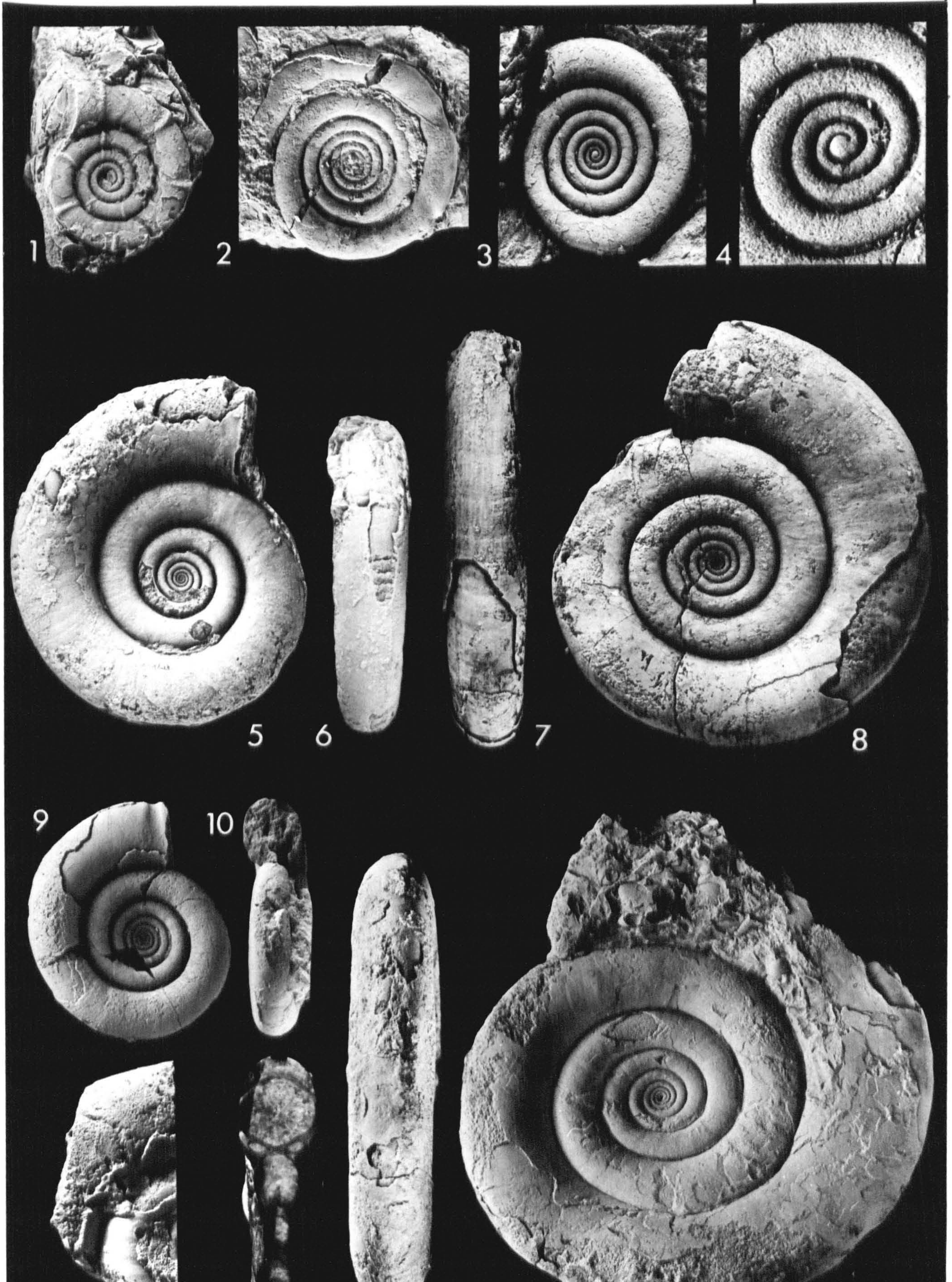

Plate 5.19

All illustrations are natural size unless otherwise indicated.

Ornatoclymenia ornata (Münster 1834)

Fig. 1, x3: Mbg; Ziegelei Müller, Üllendahl, Elberfeld.

Figs. 2,3, x2: BSP AS VII 551; Münster Collection, Schübelhammer, Oberfranken. Figured by Gümbel, 1863, pl. XVIII, figs. 10a-c.

Figs. 5-7, x2: proposed lectotype, BSP AS VII 550; Münster Collection, Schübelhammer, Oberfranken.

Figs. 12,13, x2: MfN; ?Münster Collection, Schübelhammer, Oberfranken.

Piriclymenia piriformis (Schmidt 1924)

Fig. 4, x3: MfN; Schindewolf Collection, south south east of Dahlsen (Neheim-Hüsten). Figured by Schindewolf 1937a, fig. 4.

Figs. 8,9, x2: lectotype, MfN; ?Lotz Collection, labelled Estinghausen/Hömberg.

Sulcoclymenia sulcata (Schindewolf 1923a)

Figs. 10,11, x3: proposed lectotype, Mbg 3129a: Schindewolf Collection, Bed 10, Kirch-Gattendorf, Oberfranken.

Fig. 14,15, x3: HU P82.1; sample 388/3, Geuser, Oberfranken.

Figs. 16,17, x4: Mbg 3129b; Schindewolf Collection, Bed 10, Kirch-Gattendorf, Oberfranken.

Sulcoclymenia aff. sulcata (Schindewolf 1923a)

Fig. 18, x3: HU P82.2; sample 403/6, Wäschholz, Oberfranken.

Sulcoclymenia sulcata (Schindewolf 1923b)

Fig. 19, x2: KW 2065; Wunderlich Collection, Wäschholz, Oberfranken.

PLATE 5.19

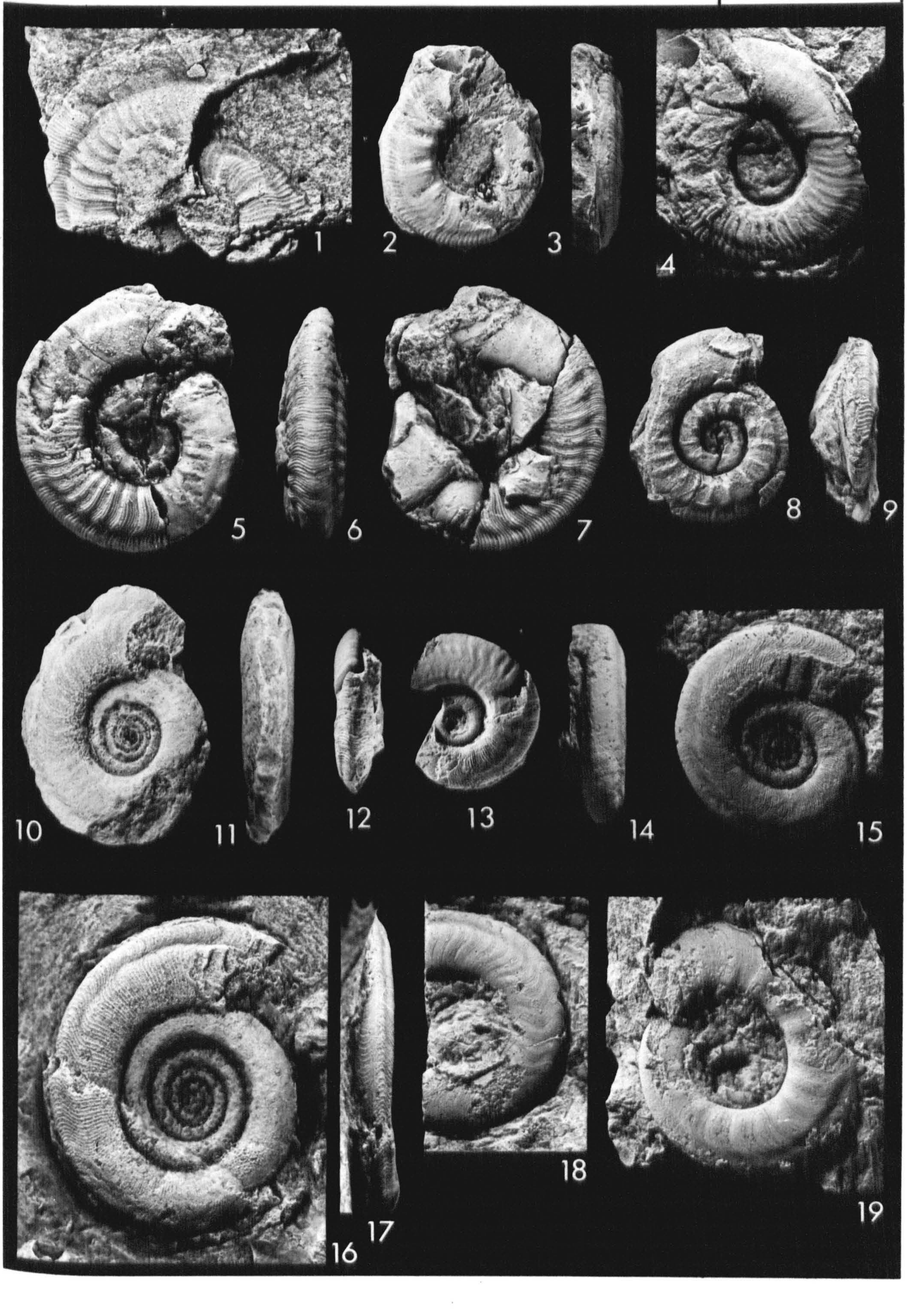

Plate. 5.20

All illustrations are natural size unless otherwise indicated.

Clymenia spiratissima (Schindewolf 1923a)

Figs. 1, x2: BM C83292; ?Münster Collection, Schübelhammer, Oberfranken.

Clymenia laevigata (Münster 1831)

Fig. 2: BM C82328; Münster Collection, Schübelhammer, Oberfranken.

Kosmoclymenia (Group II) sublaevis (Münster 1832)

Fig. 3, x4, Fig. 4, x1½: BM 81830; Münster Collection, Schübelhammer, Oberfranken. Fig. 3 shows the course of the growth-lines over the venter.

Ornatoclymenia ornata (Münster 1834)

Figs. 5-7, x2: SM H10382; Münster Collection, Schübelhammer, Oberfranken.

Clymenia laevigata (Münster 1831)

Figs. 8,9: SM H10368; Münster Collection, Schübelhammer, Oberfranken.

Figs. 12,13: SM H10365; Münster Collection, Schübelhammer, Oberfranken.

Figs. 14,15: BSP; Münster Collection, Schübelhammer, Oberfranken.

Clymenia aff. spiratissima (Schindewolf 1923a)

Figs. 10,11: SM H10364; Münster Collection, Schübelhammer, Oberfranken.

Protoxyclymenia cf. serpentina (Münster 1832)

Figs. 16,17: BM C34762; Lee Collection, Schübelhammer, Oberfranken.

PLATE 5.20

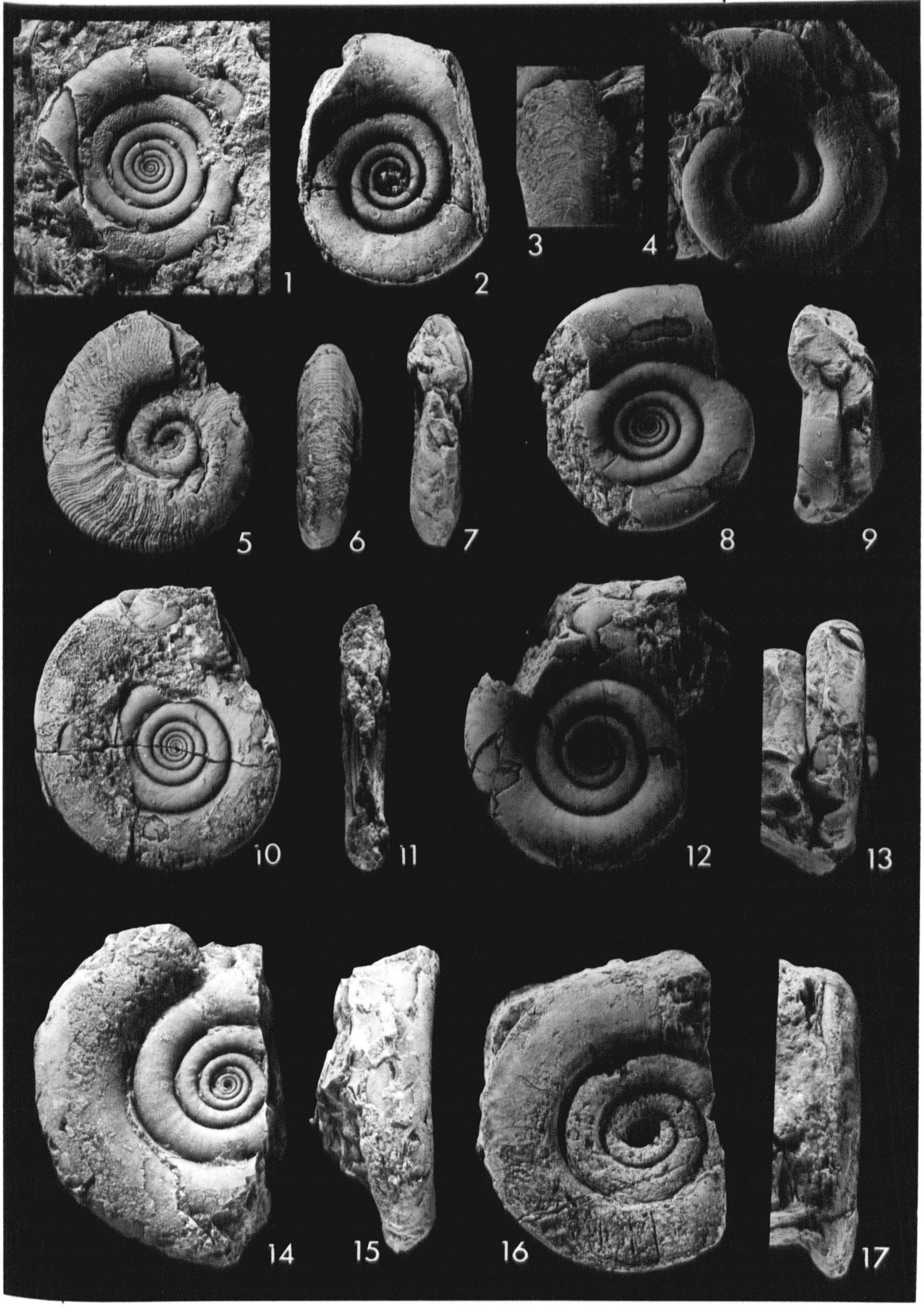

Plate 5.21

All illustrations are natural size unless otherwise indicated.

Kosmoclymenia (GroupI) _inaequistriata_

Figs. 1, x2; 2, x4: HU P82.8; _Clymenia_ Stufe, Müssenberg, Sauerland. This specimen shows growth-lines which continue over the ventro-lateral shoulder to form a pair of raised flares running around the ventral margin. Also the aperture shows what is interpreted as adult modification, where there are plicate ribs and an elongation of the ventro-lateral growth-line salient.

Figs. 4, x2; 5, x3; 7, x4: HU P82.10; _Wocklumeria_ Stufe, Hövel, Sauerland. This specimen has a series of contiguous low spines. The wrinkle-layer is better shown in Pl. 5.23, Fig. 10.

Kosmoclymenia (Group I) _undulata_ (Münster 1832)

Figs. 3; 8, x4: HU P82.9; _Wocklumeria_ Stufe, Reigern Quarry, Sauerland. Short isolated spines project from the venter.

Kosmoclymenia (Group I) _subundulata_ (Wedekind 1914)

Fig. 6, x4: MfN; Münster Collection, Schübelhammer, Oberfranken. This specimen shows the "Externband" of German authors particularly well, consisting of a series of semicircular ridges running across the venter, crossed by a series of convergent lirae. This preservation is typical of specimens whose ventral spines or flares have been removed by preparation.

PLATE 5.21

Plate 5.22

All illustrations are natural size unless otherwise indicated.

<u>Kosmoclymenia</u> (Group II) aff. <u>sublaevis</u> (Münster 1832)

Figs. 1, x2; 2,4; 3, x2: NWGL; Ostprovinzial Steinbruch, Drewer, Sauerland.

<u>Kosmoclymenia</u> (Group I) <u>undulata</u> (Münster 1832)

Fig. 5: HU P82.11; Reigern Quarry, Sauerland. The inner whorls are very faintly ribbed.

Figs. 6,7: SMF; proposed neotype, Bed 23, Reigern Quarry, Sauerland. This large example, sectioned and illustrated in Textfig. 5.27A, shows the development of a tabulate venter with remnants of spine bases (Fig. 6), and flattened flanks on the mature body-chamber.

Figs. 8,9: BM C83295; Münster Collection, Schübelhammer, Oberfranken.

Fig. 10: HU P82.7; Reigern Quarry, Sauerland. The faintly S-shaped growth-lines which characterise this group of <u>Kosmoclymenia</u> are clearly visible on this specimen, and Fig. 2.

PLATE 5.22

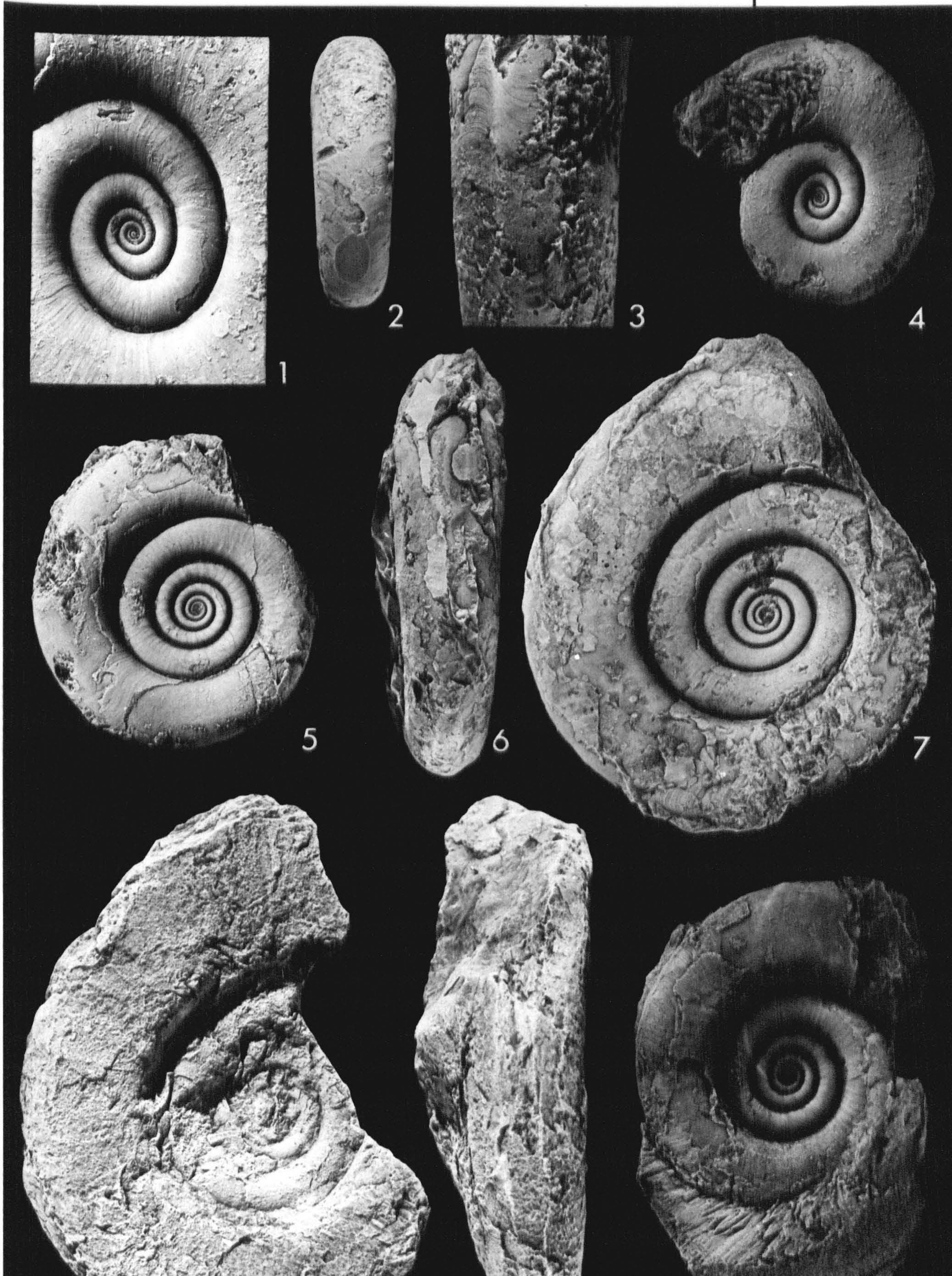

Plate 5.23

All illustrations are natural size unless otherwise indicated.

Kosmoclymenia ?linearis (Münster, 1832)

Figs. 1,2, x1½: MfN; Schindewolf Collection, Kirch-Gattendorf, Oberfranken. Labelled by Schindewolf as Oxy. linearis.

Kosmoclymenia (Group I) inaequistriata (Münster 1832)

Figs. 3, x2½; 4, x3: SM H10377, Münster Collection, Schübelhammer, Oberfranken. This specimen shows the normal mode of preservation of the venter of Kosmoclymenia. The spines themselves have been broken off during preparation, leaving the characteristic half-circle bases with converging lirae between them (see also Pl. 5.29, Fig. 4).

Kosmoclymenia cf. subundulata (Wedekind 1914)

Figs. 5-7, x2; 8,9, x6: SM H10389; Münster Collection, Schübelhammer, Oberfranken. This particularly well preserved specimen shows the effect of shell damage and the dorsal wrinkle-layer. Shell damage is visible on both sides of the shell (Figs. 6-9). Immediately following an oblique fracture of the apertural region shell secretion has resumed from a point just inside it so that the two shell layers overlap. The irregular margin of the fracture was rapidly infilled by shell growth (Fig. 8). The growth-lines are continuous over the ventral band, and a further six growth-lines were formed beyond the former aperture, before spine growth was resumed, where there are again a disproportionate number of flank to ventral growth-lines.

The dorsal wrinkle-layer consists of a series of sub-parallel sinuous ridges, running from side to side and confined to the overlapped area of the preceding whorl (Fig. 8). The thin string-like keel formed on the venter of clymeniids, can be clearly seen. This is also confined to the overlapped area, and it is overlain by the wrinkle-layer. Traces of the umbilical seams, delimiting the overlapped area are visible in Fig. 8.

Kosmoclymenia (Group I) inaequistriata (Münster 1832)

Fig. 10, x10: HU P82.10; Hövel, Sauerland, Clymenia Stufe. The pockled texture is interpreted as a mould of the original shell texture on the internal ventral surface of the body chamber. The arcuate ridges are coincident with spine bases (see also Pl. 5.21, Figs. 1,2).

PLATE 5.23

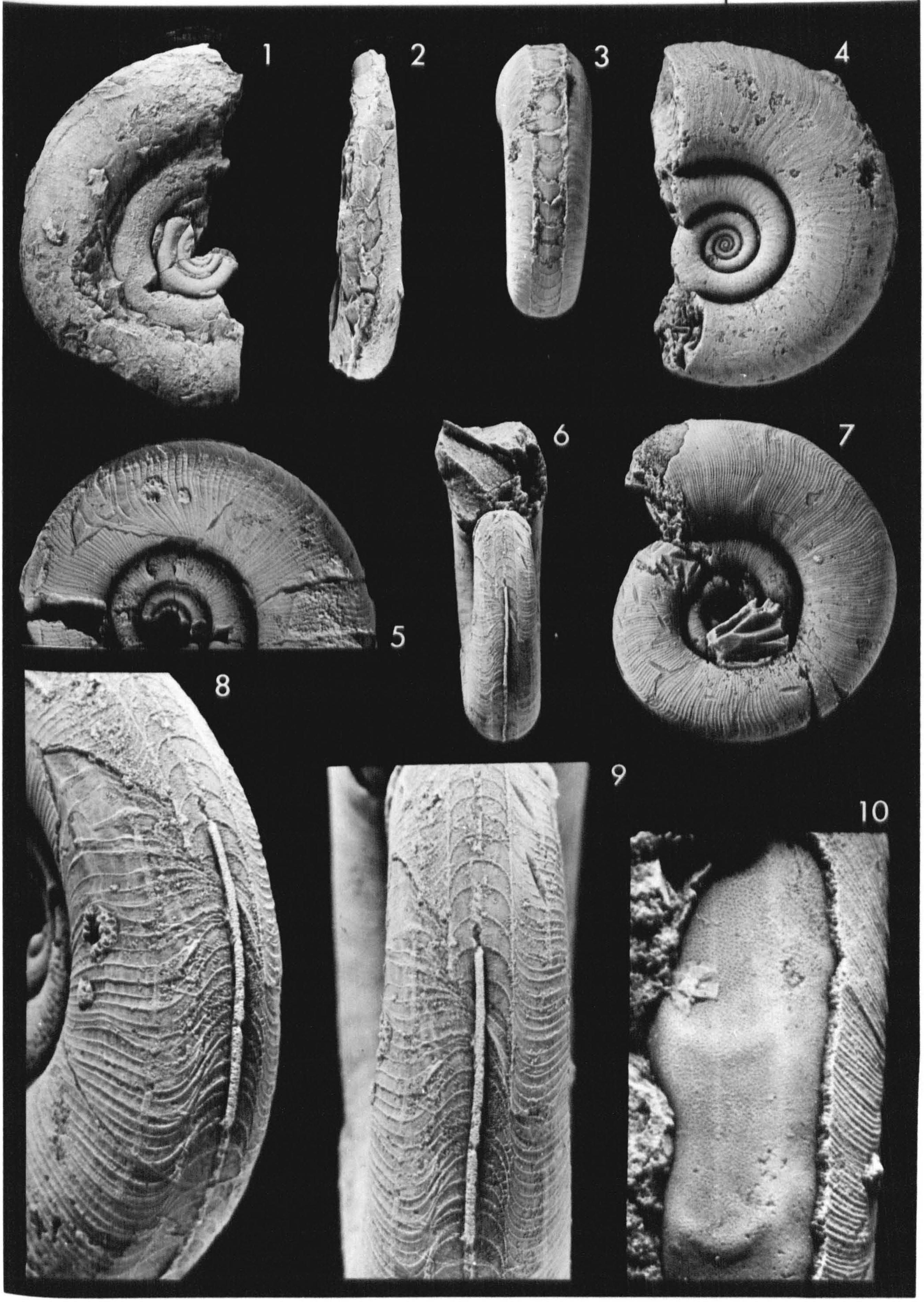

Plate 5.24

All illustrations are natural size unless otherwise indicated.

Kosmoclymenia (Group I) cf. inaequistriata (Münster 1832)

Figs. 1,2: BSP AS VII 597; Münster Collection, Schübelhammer, Oberfranken. Figured by Gümbel 1863, pl. XVII, figs. 4a,b.

Kosmoclymenia (Group III) cf. bisulcata (Münster 1840)

Figs. 3,4: Wsb; Petherwin Beds, ?Petherwin, Cornwall.

Kosmoclymenia (Group I) sp. a

Figs. 5,6: BSP 1886 III 27; Dzikowiec, Poland.

Kosmoclymenia (Group I) inaequistriata (Münster 1832)

Figs. 7,8: MfN c541; Denckmann Collection, Dasberg. Figured as Oxyclymenia undulata var. elegantula by Schmidt 1924, pl. 7, figs. 7,a.

Figs. 9-11: proposed lectotype SM H10376; Münster Collection, Schübelhammer, Oberfranken.

Kosmoclymenia (Group I) subundulata (Wedekind 1914)

Figs. 12,13: Mbg/MfN; Schindewolf Collection, Bed 18, upper Clymenia Stufe, Kirch-Gattendorf, Oberfranken. Figured by Schindewolf 1923a, pl. XVIII, fig. 8.

Figs. 14,15: MfN c597; Schindewolf Collection, Ense, Wildungen. Figured by Schindewolf 1957, textfig. 41.8.

Fig. 16: proposed lectotype, GPI; Wedekind Collection, Dasberg, Sauerland.

Figs. 17,18, x1½: MfN/Mbg; Schindewolf Collection, Bed 18, upper Clymenia Stufe, Kirch-Gattendorf, Oberfranken. Figured by Schindewolf 1923a, pl. XVIII, fig. 9.

Kosmoclymenia (Group I) linearis (Münster 1832)

Figs. 19,10, x1½: MfN/ex Mbg; Schindewolf Collection, Bed 20, lower Wocklumeria Stufe, Kirch-Gattendorf, Oberfranken. Figured by Schindewolf 1923a, pl. XVIII, fig. 7.

PLATE 5.24

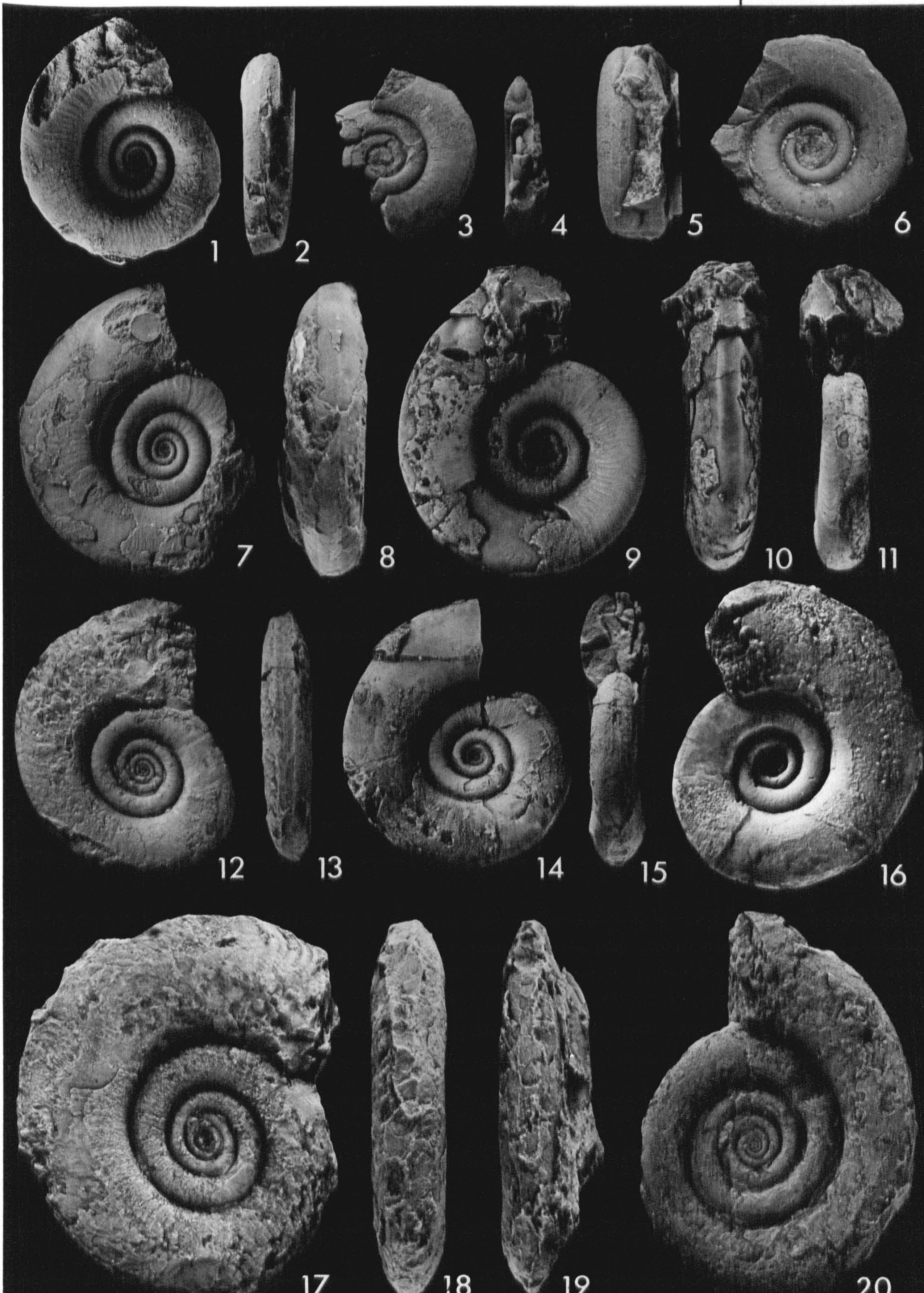

Plate 5.25

All illustrations are natural size unless otherwise indicated.

Kosmoclymenia (Group II) sp. f

Figs. 1,2: MfN; von Buch Collection, Dzikowiec, Poland. The growth-lines over the flanks are barely biconvex, and the ratio of growth-lines on the flank and venter is 1:1.

Figs. 10,11: MfN c544; Dzikowiec, Poland.

Kosmoclymenia (Group II) carinata (Ansted 1838)

Figs. 3,4: holotype SM H4011; Ansted Collection, ?Petherwin Beds, Launceston, Cornwall. Figured by Ansted 1838, pl. VIII, figs. 2.

Kosmoclymenia (Group II) sublaevis (Münster 1832)

Figs. 5,6: proposed holotype BSP AS VII 540; Münster Collection, Schübelhammer, Oberfranken.

Kosmoclymenia (Group II) aff. sp. e

Figs. 7-9, x2: SM H10399; Münster Collection, Schübelhammer, Oberfranken. Although this specimen is small it has a distinctive whorl cross-section and widely spaced faint rursiradiate growth-lines.

Kosmoclymenia (? Group II) coronata (Schmidt 1924)

Figs. 12, x3; 13, x2: proposed lectotype, MfN; Denckmann Collection, Dasberg, Sauerland.

Kosmoclymenia (Group II) wocklumeri (Wedekind 1914)

Figs. 14; 17, x4: BM 81854; Münster Collection, Schübelhammer, Oberfranken. The growth-lines (Fig. 17) are so rursiradiate that they are no longer biconvex, consisting simply of a convex salient over the flank, and a ventral sinus.

Kosmoclymenia (Group II) sp. d

Figs. 15, x2; 16, x3: Univ. Erlangen-Nürnberg 80; Münster Collection, Elbersreuth, Oberfranken. The uninterrupted course of the growth-lines over the venter, characteristic of this group, can be seen in Fig. 16.

PLATE 5.25

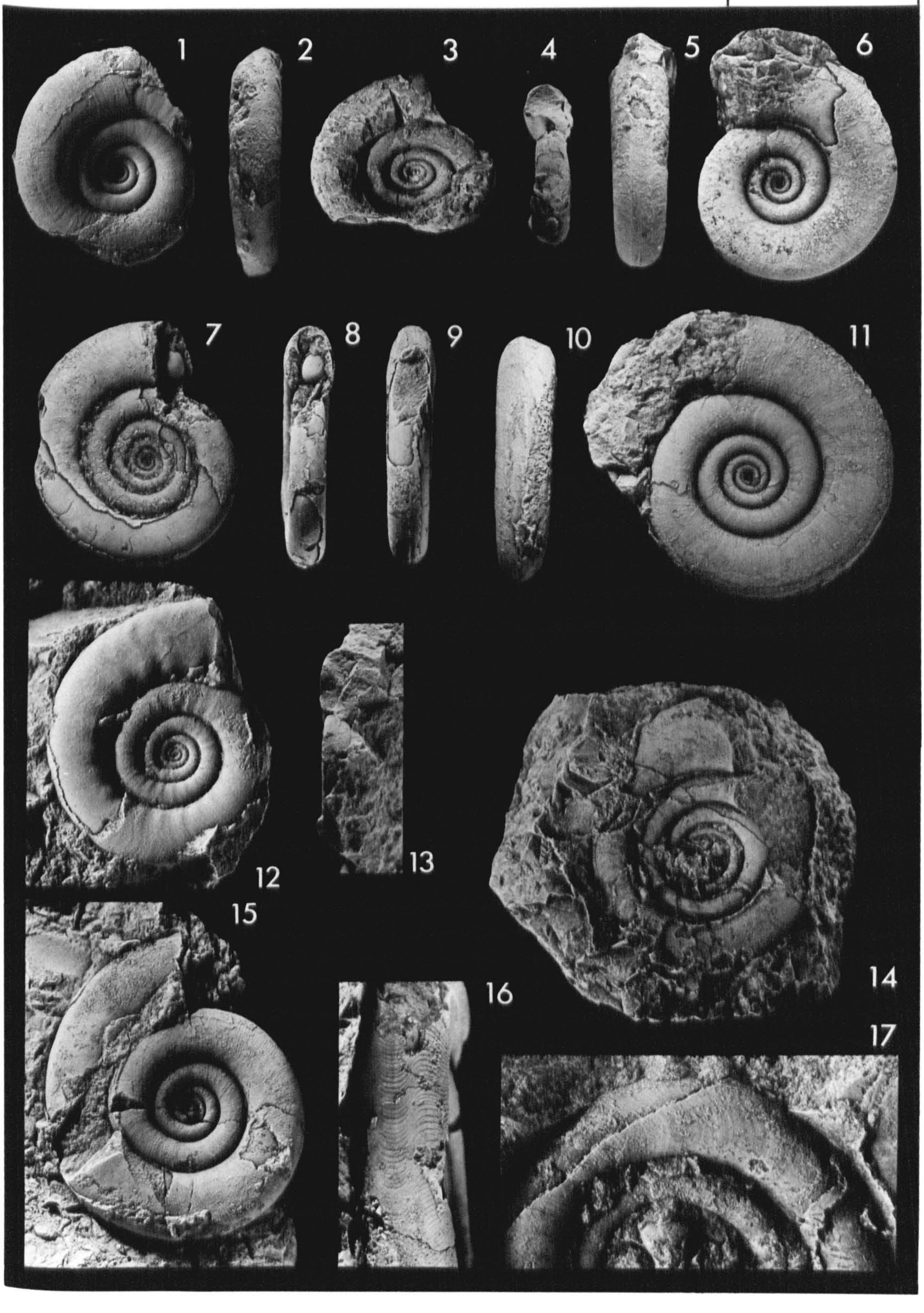

Plate 5.26

All illustrations are natural size unless otherwise indicated.

<u>Kosmoclymenia</u> (Group III) <u>colubrina</u> (Lange 1929)

Fig. 1, x2: MfN; ? Wildungen, Kellerwald.

<u>Kosmoclymenia</u> (Group III) <u>colubrina</u> (Lange 1929)

Figs. 2,3,4: holotype MfN; <u>Clymenia</u> Stufe, Dasberg, Sauerland. Figured by Lange 1929, pl. 3, fig. 39.

Figs. 4,5,x2: MfN; Zwester Weg, Ense, Wildungen, Kellerwald.

<u>Kosmoclymenia</u> (Group III) aff. sp. <u>h</u>

Fig. 6, x2: SM H10400; Münster Collection, Schübelhammer, Oberfranken.

<u>Kosmoclymenia</u> (Group III) sp. <u>h</u>

Figs. 7,8, x2: MfN; Otto Collection, Dzikowiec, Poland.

<u>Kosmoclymenia</u> (Group III) <u>bisulcata</u> (Münster 1840)

Fig. 9, x1½; Figs. 12,13: proposed lectotype, BSP AS VII 543; Münster Collection, Schübelhammer, (photographs for Figs. 12,13 kindly provided by M. R. House).

<u>Protoxyclymenia</u> <u>serpentina</u> (Münster 1832)

Figs. 10,11: holotype, BSP AS VII 535; Münster Collection, Schübelhammer, Oberfranken.

<u>Kosmoclymenia</u> aff. <u>bisulcata</u> (Münster 1840)

Figs. 14,16; 15, x1½: HU P82.12; collected loose, Reigern Quarry, Sauerland.

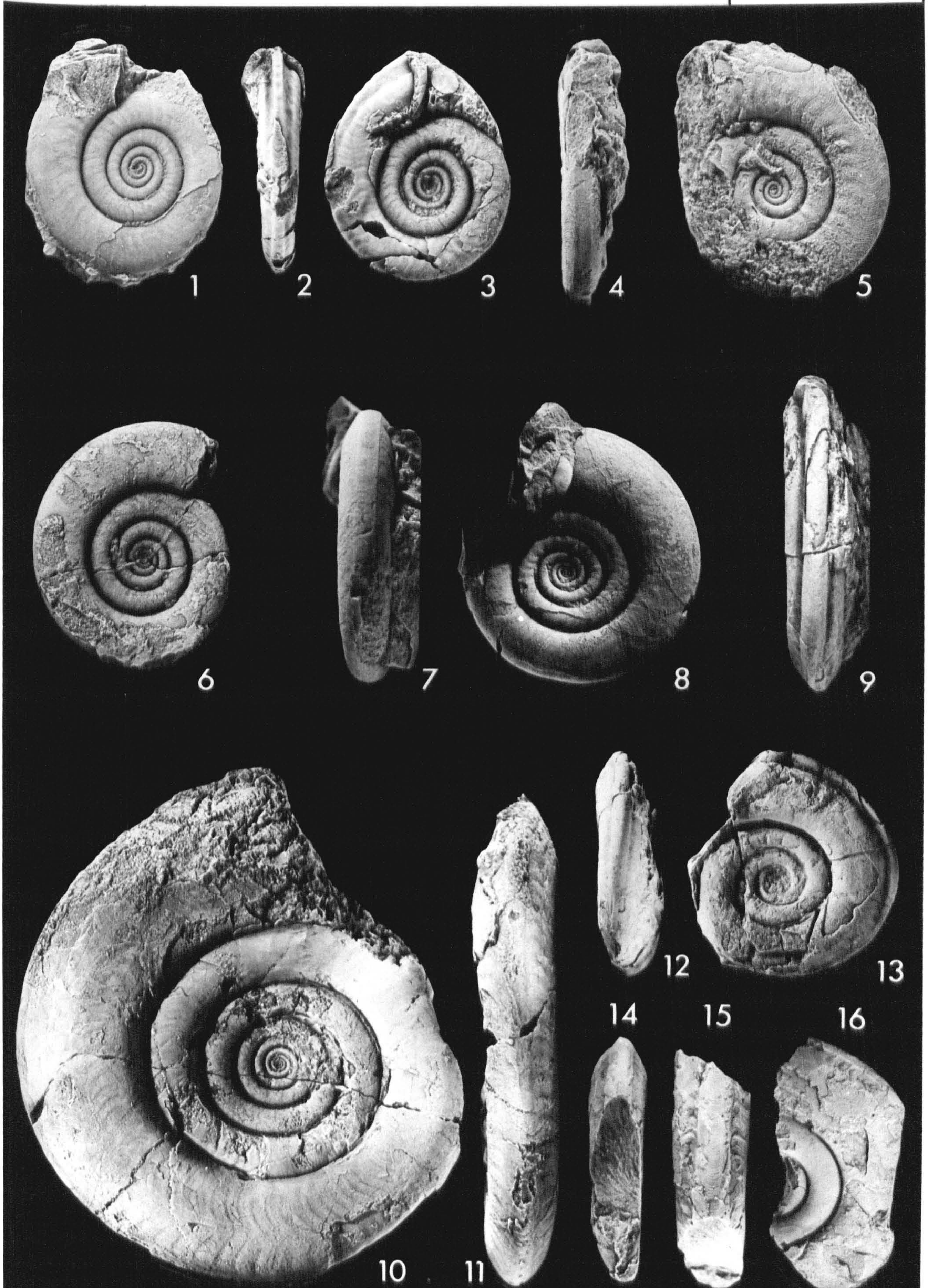
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Plate 5.27

All illustrations are natural size unless otherwise indicated.

Kosmoclymenia (Group IV) aff. similis (Münster 1839)

Figs. 1,2, x2: Mbg; Drevermann Collection, Langenaubach.

Figs. 3,4,5, x2: Mbg; Kreigen Collection, Langenaubach.

Kosmoclymenia (Group IV) aff. similis (Münster 1839)

Fig. 6, x1½: MfN; Dzikowiec, Poland.

Kosmoclymenia (Group IV) sp. i

Figs. 7-9, x1½: MfN c595; Beyrich Collection, Dzikowiec, Poland.

Kosmoclymenia (Group I) subundulata (Wedekind 1914)

Figs. 10-12: MfN; Münster Collection, Schübelhammer, Oberfranken.

Kosmoclymenia (Group IV) semistriata (Münster 1839)

Figs. 16,17, x2: proposed lectotype, BSP AS VII 532; Münster Collection, Schübelhammer, Oberfranken. Figured by Gümbel 1863, pl. XVII, fig. 6.

Kosmoclymenia (Group IV) similis (Münster 1839)

Figs. 13,14, x2: Mbg 3133; Schindewolf Collection, Bed 20, lower Wocklumeria Stufe, Kirch-Gattendorf, Oberfranken.

Fig. 15, x2: proposed lectotype, BSP AS VII 544; Münster Collection, Schübelhammer, Oberfranken. ? Figured by Gümbel 1863, pl. XVII, figs. 5a-d.

Kosmoclymenia (Group I) subundulata (Wedekind 1914)

Figs. 18, x1½: SM H10388; Münster Collection, Schübelhammer, Oberfranken.

Kosmoclymenia (Group II) sp. g

Figs. 19, 20: MfN; Dzikowiec, Poland.

PLATE 5.27

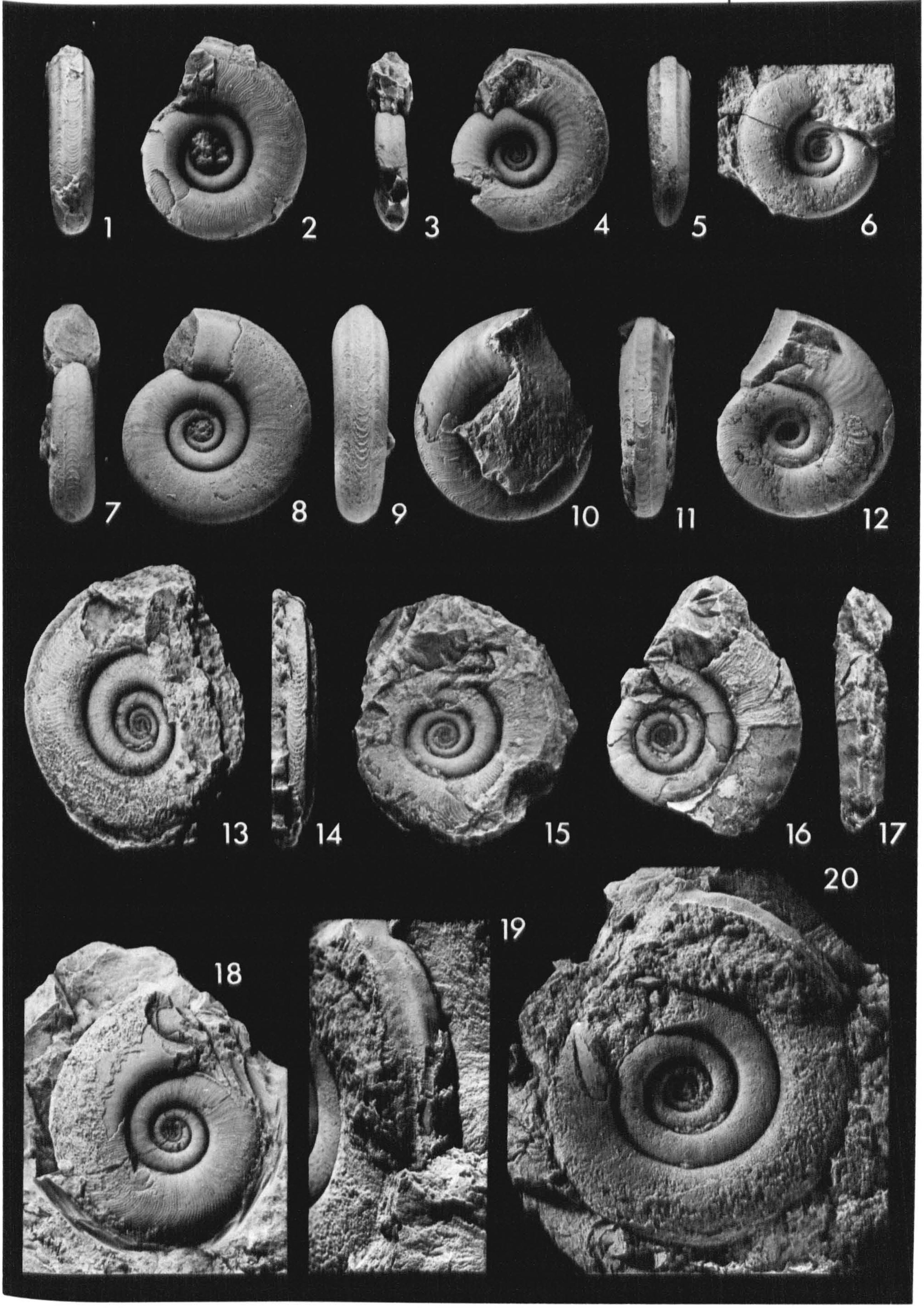

Plate 5.28

All illustrations are natural size unless otherwise indicated.

<u>Protoxyclymenia</u> <u>dunkeri</u> (Münster 1839)

Fig. 1, x1½: proposed lectotype, BSP AS VII 559; Münster Collection, Gattendorf, Oberfranken. ?Figured by Gümbel 1863, pl. XVI, figs. 3a-c.

Figs. 4,5, x1.66: 80D 6403.2 Korn Collection, Wäschholz, Oberfranken.

<u>Kosmoclymenia</u> (Group I) <u>subundulata</u> (Wedekind 1914)

Figs. 2, x5; 10,11, x1½: SM H10390; Münster Collection, Schübelhammer, Oberfranken.

Figs. 3, x8; 6,7, x2: HU P82.13; Hövel, Sauerland.

<u>Genuclymenia</u> cf. <u>karpinskii</u> (Perna 1914)

Figs. 8,9,12,13, x2: MfN; Estinghausen or Hömberg.

<u>Protoxyclymenia</u> <u>serpentina</u> (Münster 1832)

Figs. 14,15: KW 2077; Wunderlich Collection, Beil.

PLATE 5.28

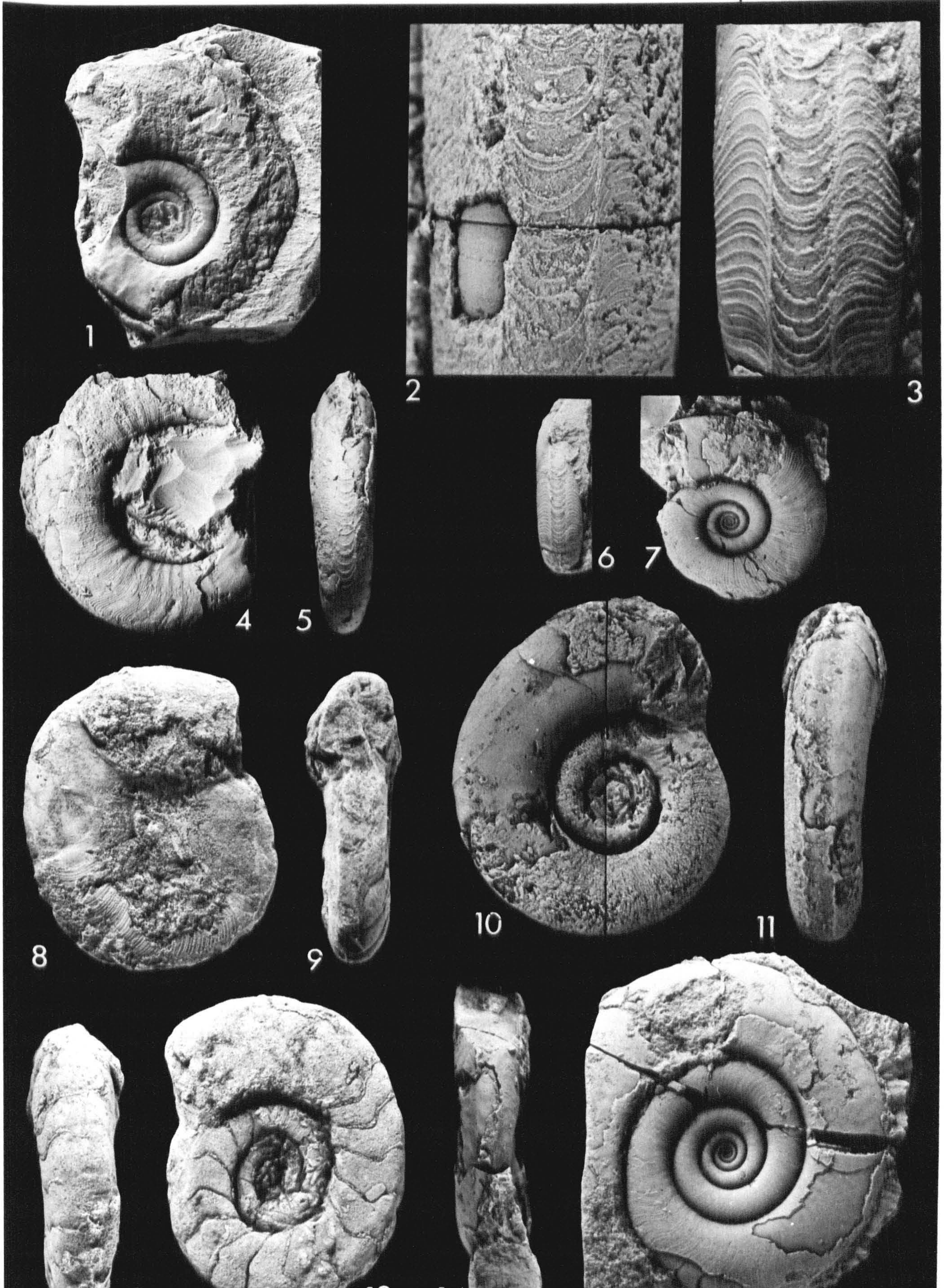

Plate 5.29

All illustrations are natural size unless otherwise indicated.

<u>Kosmoclymenia</u> (Group I) <u>subundulata</u> (Wedekind 1914)

Figs. 1-3, x4: HU P82.14; Beil. Shows the nature of the dorsal wrinkle-layer over the impressed part of the flanks and the venter.

<u>Kosmoclymenia</u> (Group I) sp.

Figs. 4, x5; 5,6, x2: HU P82.15; Beil. Shows the nature of the ventral band, and the lirae running between adjacent spine bases.

<u>Kosmoclymenia</u> (Group I) <u>inaequistriata</u> (Münster 1832)

Figs. 7, x2; 8, x5; 9, x6: KW 2080; Kasberg, Langenholthausen. Shows the nature of shell repair, and the associated loss of ventral spines.

Figs. 10, x10; 11, x10; 12, x3: KW 2093. Fig. 10 shows the ventral wrinkle-layer impression, and Fig. 11 is a close-up of Fig. 12, showing moulds of borings into the internal side of the flank.

PLATE 5.29

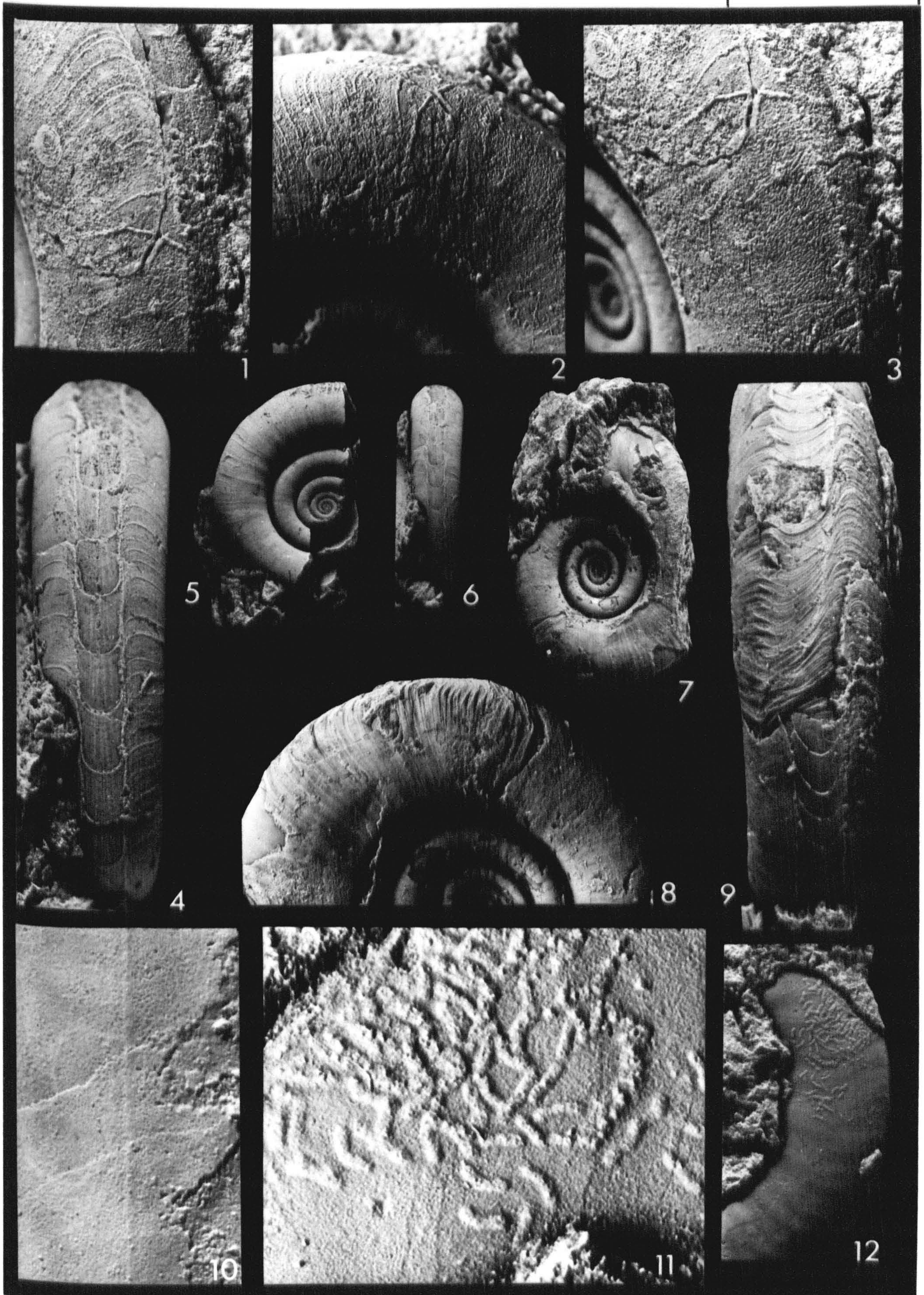

Plate 5.30

All illustrations are natural size unless otherwise indicated.

Gen. Nov. F stuckenbergi (Tokarenko 1903)
Figs. 1,2, x2: KW 2058; Beil, Sauerland.
Gen. Nov. F ?decorata (Münster 1840)
Fig. 3, x2½: MfN; Münster Collection, Geuser, Oberfranken.
Figs. 4, x10; 8, x5: BSP AS VII 533; Münster Collection, Geuser, Oberfranken.
Gen. Nov. F aff. costata (Münster 1842)
Fig. 5, x1½: BSP AS VII 529; Münster Collection, Geuser, Oberfranken.
Gen. Nov. F costata (Münster 1842)
Figs. 6,7, x2: proposed lectotype, BSP AS VII 606; Münster Collection, Geuser, Oberfranken. Figured by Münster 1842 pl. XI, figs. 16a,b.
Gen. Nov. F aff. subflexuosa (Münster 1840)
Fig. 9, x4: BSP AS VII 527; Münster Collection, Geuser, Oberfranken.
Gen. Nov. F subflexuosa (Münster 1840)
Figs. 10,11, x4: BSP AS VII 526, holotype; Münster Collection, Geuser, Oberfranken. Figured by Gümbel 1863, pl. XV, figs. 10a-c.
Kosmoclymenia sp.
Fig. 12: BSP; Münster Collection, Schübelhammer, Oberfranken. Figured by Gümbel 1863, pl. XVII, fig. 1g.
Kosmoclymenia undulata pattisoni Selwood 1960
Figs. 13, x3; 18: GSM 87043, holotype; Selwood Collection, Stourscombe Beds (endogona Subzone), Stourscombe, Cornwall.
Kosmoclymenia aff. undulata (Münster 1832)
Figs. 14, 15, x1½: Mbg; Braunau, Wildungen, Kellerwald.
Kosmoclymenia colubrina (Lange 1929)
Figs. 16, x2; 17: KW 2081; Dasberg summit, Sauerland.

PLATE 5.30

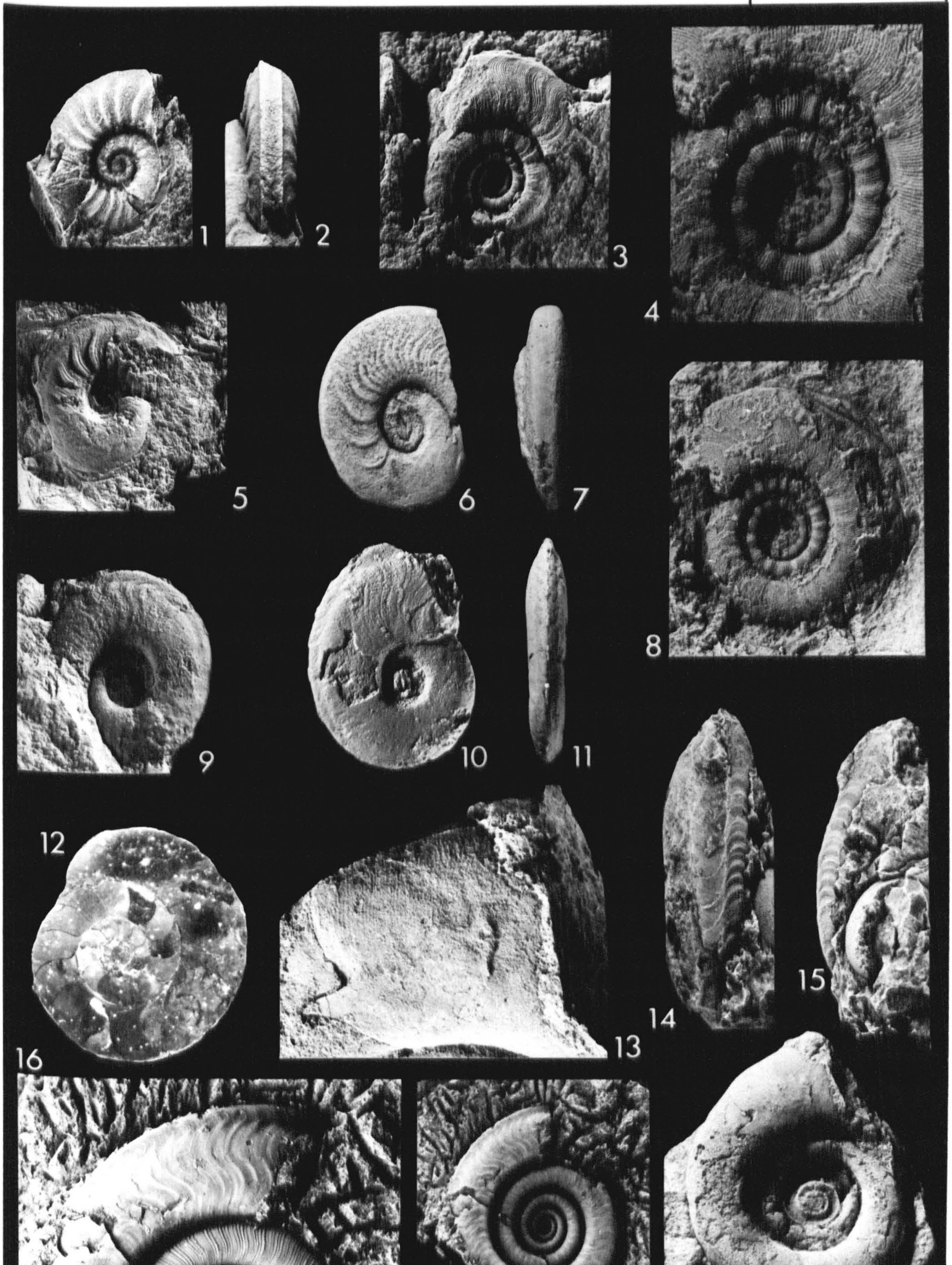

Plate 5.31

All illustrations are natural size unless otherwise indicated.

Gen. Nov. D flexuosa (Münster 1840)

Fig. 1, x1½: Mbg 3121; Schindewolf Collection, Bed 11, Kirch-Gattendorf, Oberfranken.

Fig. 2, x2: BM 81856, proposed neotype; Münster Collection, Geuser, Oberfranken.

Gen. Nov. E sp. b

Fig. 3, x2: BSP AS VII 528; Münster Collection, Geuser, Oberfranken.

Gen. Nov. D acuta (Schmidt 1924)

Figs. 4-6, c1½: MfN; Zwester Weg, Ense, Wildungen. Figured as Cyrtoclymenia acuta by Schmidt 1924, pl. 6, figs. 30,a.

Gen Nov. D kayseri (Drevermann 1901)

Fig. 7, x2.66: BSP AS VII 523; Münster Collection, Geuser, Oberfranken.

Fig. 8, x3: 348/1; Geuser, Oberfranken.

Rectoclymenia arietina (Sandberger 1853)

Figs. 9,10, x2: Wsb; Sandberger Collection, Enkeberg, Sauerland. Figured by Sandberger 1853, pl. VII, figs. 5a-c.

Gen. Nov. F ?subflexuosa (Münster 1840)

Figs. 11,12: Mbg 3021; Schindewolf Collection, Bed 11, Kirch-Gattendorf, Oberfranken.

Gen. Nov. D sp.

Figs. 13,14: GT 2015; Beil, Sauerland.

Figs. 15,16: KW 2076; Beil, Sauerland.

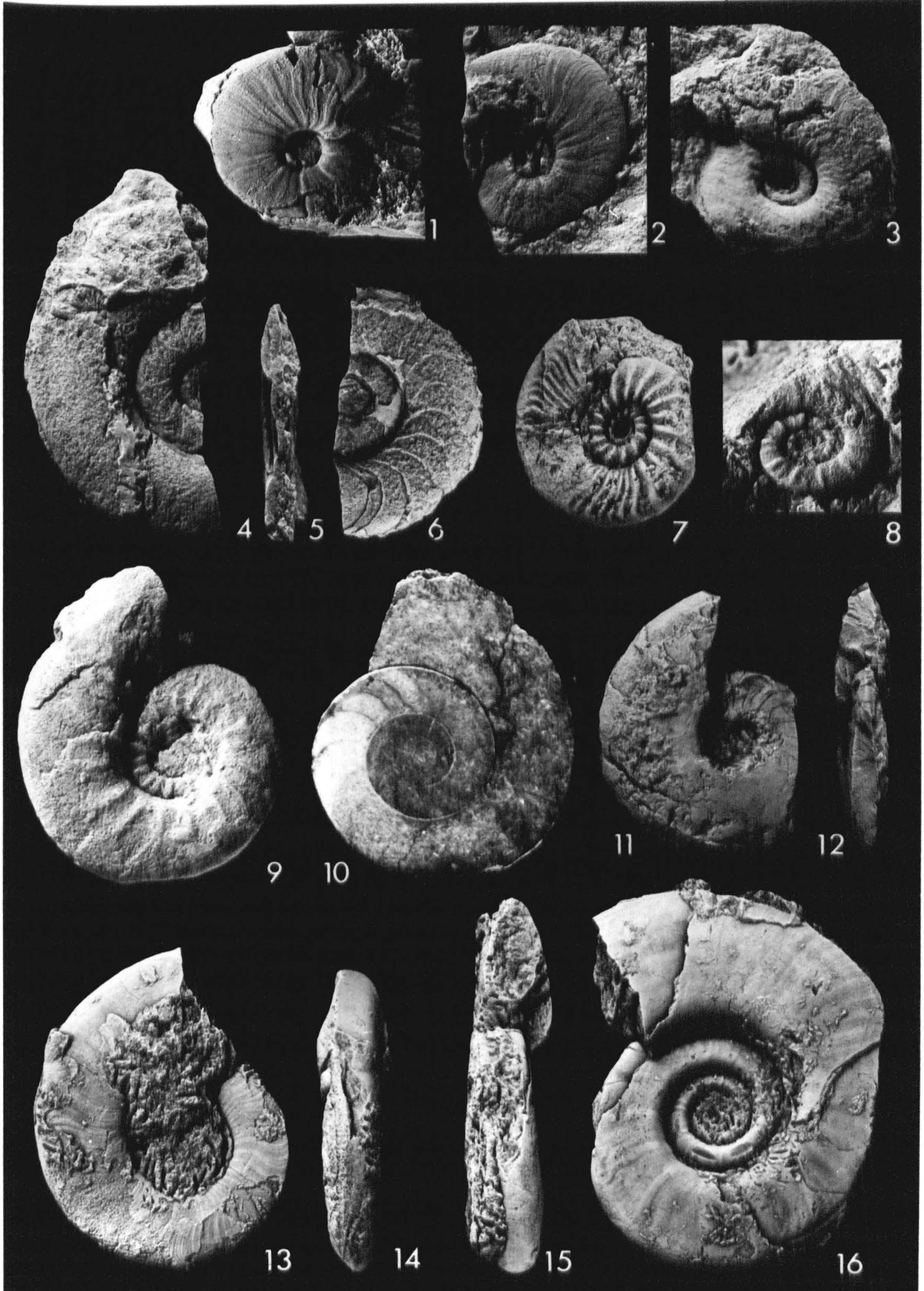
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Plate 5.32

All illustrations are natural size unless otherwise indicated.

<u>Carinoclymenia</u> <u>beuelensis</u> (Lange 1929)

Figs. 1-3,6, x1½; 9, x10; 10, x3: KW 2070; <u>annulata</u> Zone, Beil, Sauerland. Figs. 9 and 10 are enlargements of small areas visible on Fig. 6. Fig. 9 shows the internal mould of the pit-like ventral wrinkle-layer, and Fig. 10 shows the anastomosing radial striations of the dorsal wrinkle-layer.

Fig. 4, x4: GT 2021; <u>annulata</u> Zone, Beil, Sauerland. This specimen shows particularly well the serrate nature of the ventral margin, resulting from the formation of weak riblets.

Fig. 5, x4: GT 2022; <u>annulata</u> Zone, Beil, Sauerland.

Fig. 7, x4: GT 2023; <u>annulata</u> Zone, Beil, Sauerland.

Fig. 8: MfN; Bed 1, <u>annulata</u> Zone, Alte Heerstrasse, Öttersdorf, Thuringia. Specimen figured by Müller 1956, pl. 1, fig. 9.

Figs. 11,12, x2: MfN; holotype, Lange Collection, <u>annulata</u> Zone, Beil, Sauerland.

PLATE 5.32

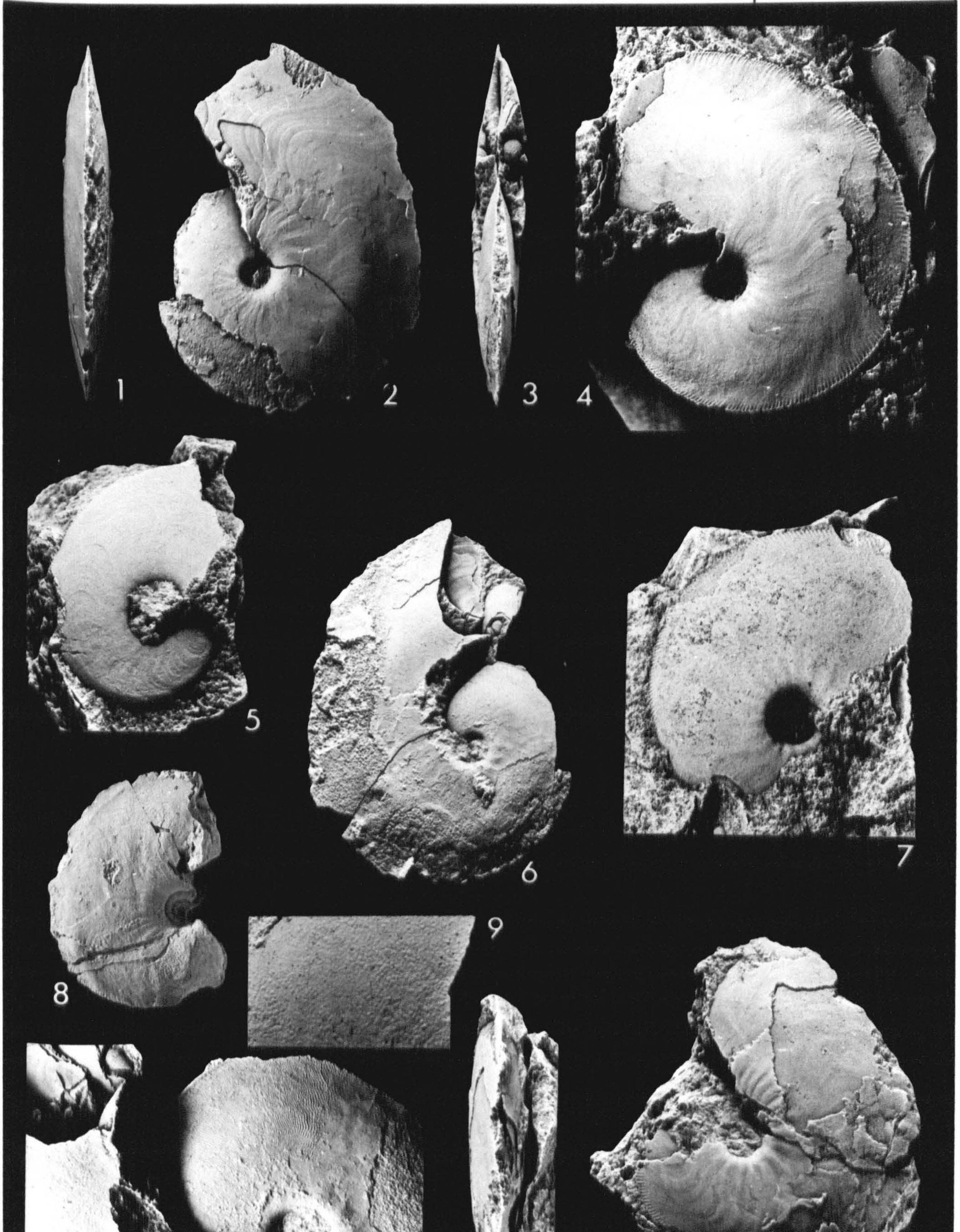

Plate 5.33

All illustrations are natural size unless otherwise indicated.

<u>Protornoceras</u> <u>planidorsatum</u> (Münster 1834)

Fig. 1, x1½: GT 2001; Trost Collection, Beil, Sauerland.

Figs. 6, x1½; 7, x2: GT 2004; Trost Collection, Beil, Sauerland.

<u>Protornoceras</u> sp.

Figs. 4,5, x1½: RE 551 734.5 A242/1; Torley Collection, Enkeberg, Sauerland.

<u>Sellaclymenia</u> <u>torleyi</u> (Wedekind 1914)

Figs. 2,3; RE 551 734.5 A254; proposed lectotype, Torley Collection, Hövel. Figured by Wedekind 1914, pl. VI, figs. 1a,b.

Figs. 14,15: MfN; ?Denckmann Collection, Beil. Figured by Schmidt 1924, pl. 7, figs. 8,a, as <u>Sell</u>. <u>spinosa</u> sp. nov. (proposed as the lectotype).

<u>Endosiphonites</u> (<u>Endosiphonites</u>) <u>bowsheri</u> (Miller and Collinson 1951)

Figs. 8,9: SM H7366; Percha Shale, Sierra County, New Mexico, USA. Figured by Miller and Collinson 1951.

Gen. Nov. <u>E</u> sp. <u>a</u>

Figs. 10,12,13: Mbg; Escot Collection, La Serre, Cabrières Hérault.

Gen. Nov. <u>E</u> cf. sp. <u>a</u>

Fig. 12a, x2: MfN c429.1; Bed 27, Alte Heerstrasse, Schleiz. Figured by Brügge 1973, pl. 1, fig. 1.

Fig. 11, x3: MfN c429.3; Bed 35, Alte Heerstrasse, Schleiz. Figured by Brügge 1973, pl. 1. fig. 4.

PLATE 5.33

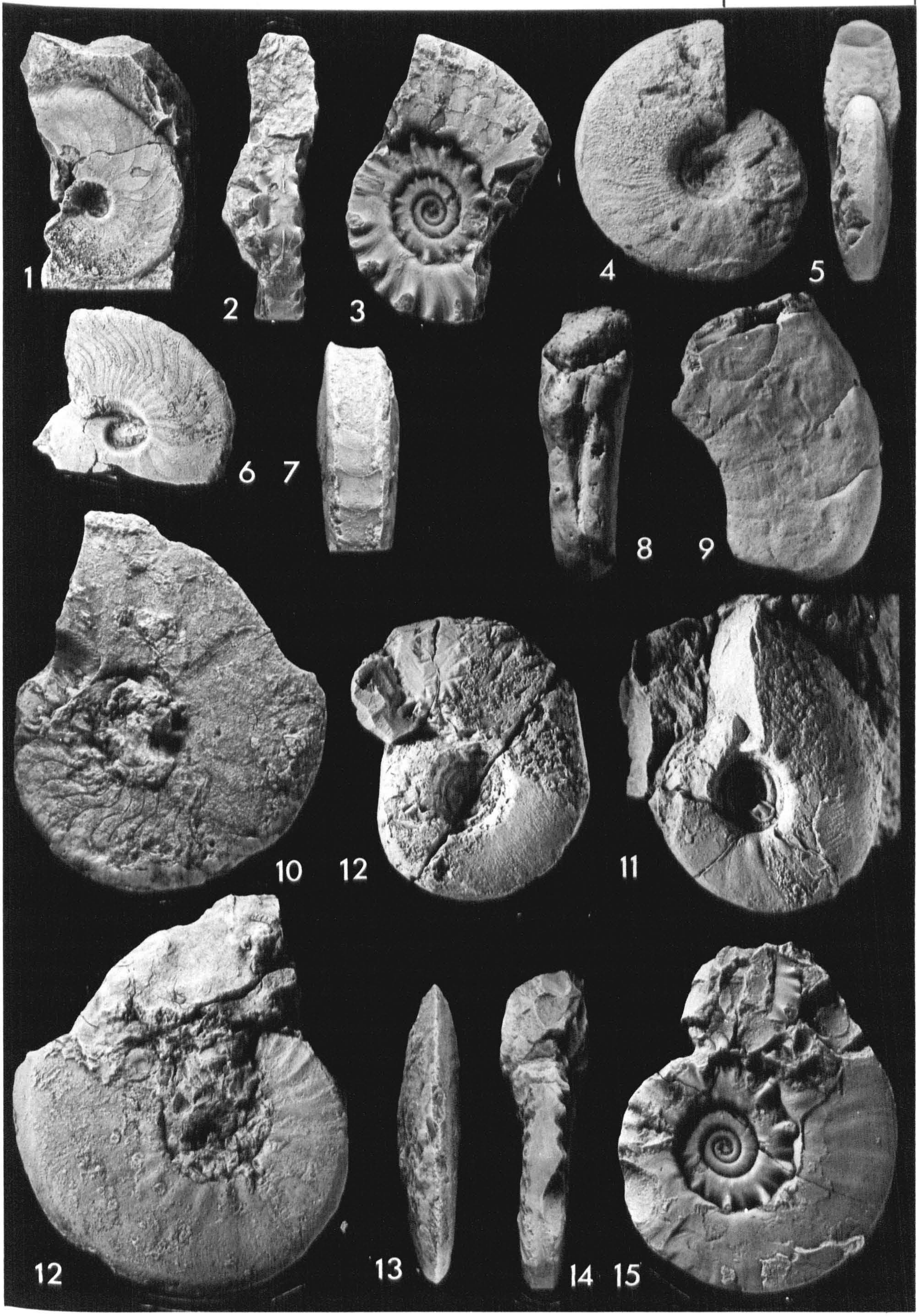

Plate 5.34

All illustrations are natural size unless otherwise indicated.

Cyrtoclymenia involuta (Wedekind 1908)

Figs. 1,2; KW 2096; Wunderlich Collection, Beringhausen.

Figs. 3-5, x1½: MfN; ?Lange Collection, Enkeberg.

Fig. 6, x2: KW 2059; Wunderlich Collection, Beil.

Platyclymenia sp.

Figs. 7,8: KW 2071; Wunderlich Collection, Beil.

Protactoclymenia enkebergensis (Wedekind 1908)

Figs. 9,10: KW 2062; Wunderlich Collection, Enkeberg,

Cyrtoclymenia angustiseptata (Münster 1832)

Figs. 11-13: proposed lectotype, BSP AS VII 585; Münster Collection, Schubelhammer, Oberfranken. Figured by Münster 1832, pl. I, figs. 3a-c.

Figs. 16,17: BSP AS VII 599; Münster Collection, Schübelhammer, Oberfranken. Figured by Gümbel 1863, pl. XV, figs. 3a-c, as Münster's original of Cl. lata.

Protactoclymenia pulcherrima Wedekind 1908

Figs. 14,15: Gött; Wedekind Collection, Enkeberg, Sauerland. Photographs by M. R. House.

Cyrtoclymenia inflata (Münster 1832)

Figs. 18,19: proposed lectotype, BSP AS VII 536; Münster Collection, Schübelhammer, Oberfranken. Figured by Münster 1832, pl. I, figs. 5a,b.

PLATE 5.34

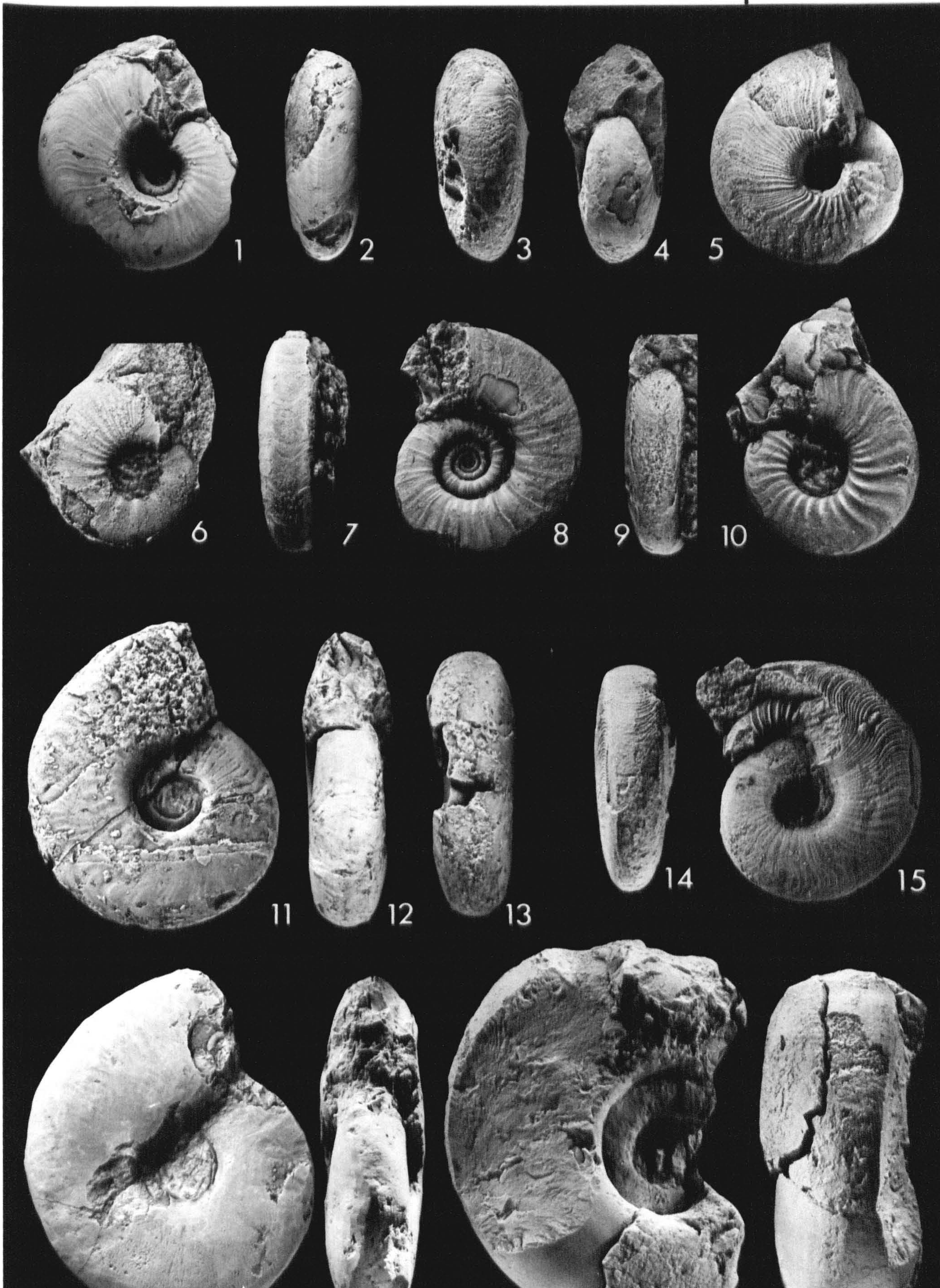

Plate 5.35

All illustrations are natural size unless otherwise indicated.

Cyrtoclymenia tetragona Schmidt 1924

Fig. 1, x4: proposed lectotype, MfN; Dasberg. Figured by Schmidt 1924, pl. 6, fig. 23.

Cyrtoclymenia plicata (Münster 1839)

Figs. 2,3, x2: MfN; Denckmann Collection, Zwester Weg, Ense. Figured by Schmidt 1924, pl. 6, figs. 29,a.
Figs. 4,5, x2: BSP; ?Münster Collection, Schübelhammer, Oberfranken. Figured by Gümbel 1863, pl. XV, fig. 6, as Cl. subnodosa.
Figs. 8-10: BSP AS VII 583; Münster Collection, Schübelhammer, Oberfranken. Figured by Münster 1839, pl. XVI, figs. 5a-c, proposed lectotype of Cl. cincta.
Figs. 15,16: MfN; Münster Collection, Schübelhammer, Oberfranken.
Figs. 17,18: proposed lectotype, BSP AS VII 584; Münster Collection, Schübelhammer, Oberfranken. Figured by Münster 1839, pl. XVI, figs. 4a-c.

Cyrtoclymenia sp.

Figs. 6,7, x1½: MfN; Riemke. Figured by Schmidt 1924, pl. 6, fig. 25, as Cl. lata. Its ribs are too narrow and frequent for that species.

Cyrtoclymenia plurisepta (Phillips 1841)

Figs. 13,14, x1½: GSM 7174; Phillips Collection, South Petherwin, Cornwall. Figured by Phillips 1841, pl. LIV, figs. 244a-c.

Cyrtoclymenia fasciata (Phillips 1841)

Figs. 11,12, x1½: GSM 7172; Phillips Collection, South Petherwin, Cornwall. Figured by Phillips 1841, pl. LIII, figs. 242a-d.

PLATE 5.35

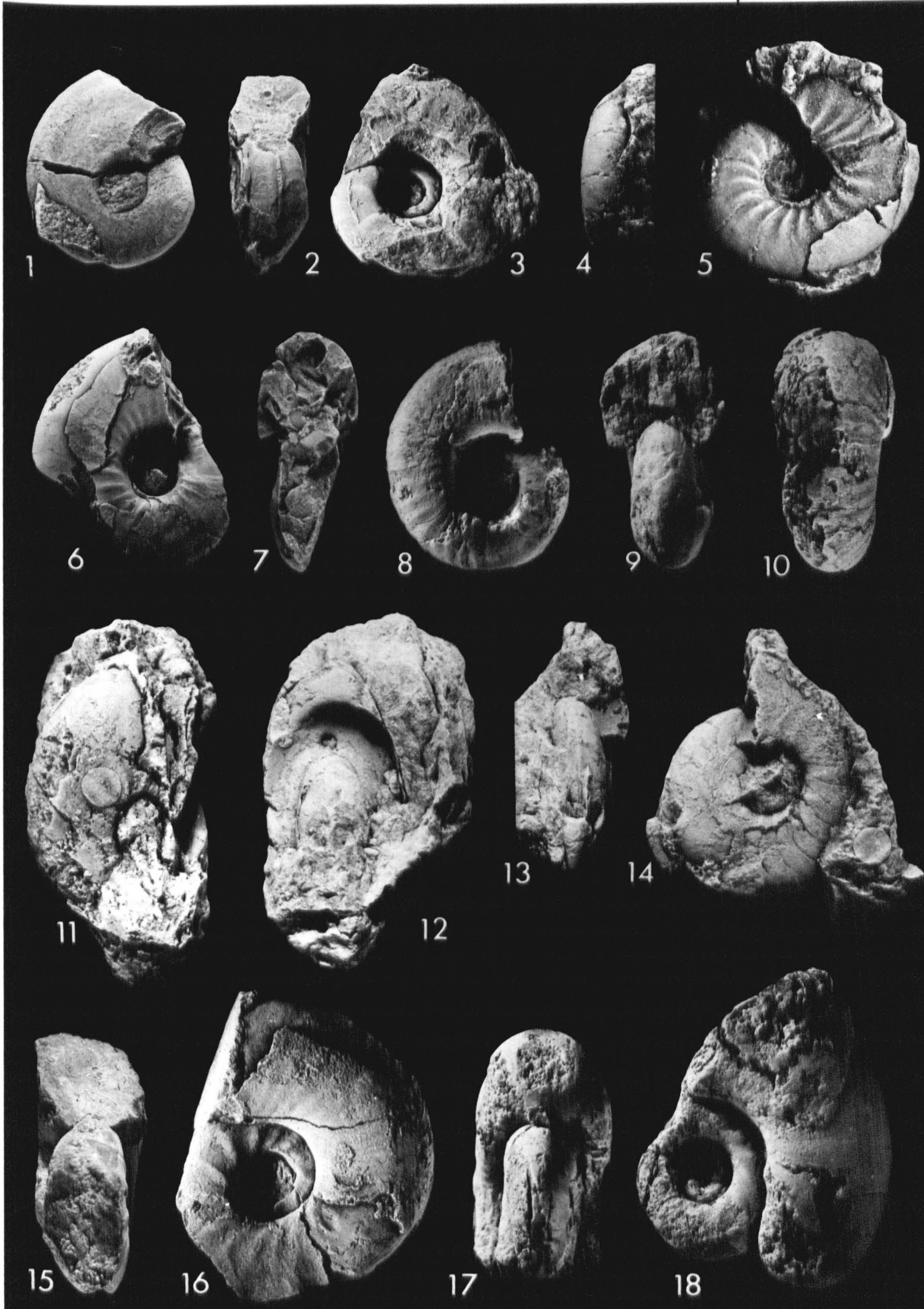

Plate 5.36

All illustrations are natural size unless otherwise indicated.

<u>Genuclymenia</u> <u>borni</u> (Schindewolf 1923a)

Fig. 1, x2: Mbg 3122; Schindewolf Collection, Bed 11, Kirch-Gattendorf, Oberfranken.

Fig. 2, x2: Mbg 3123; Schindewolf Collection, Bed 11, Kirch-Gattendorf, Oberfranken.

?<u>Platyclymenia</u> sp.

Figs. 3,4, x1½: MfN; Lange Collection, Beil. Figured by Lange 1929, pl. III, figs. 38,a.

?<u>Genuclymenia</u> sp.

Fig. 5, x2: KW 2067; Wunderlich Collection, Wäschholz.

<u>Genuclymenia</u> <u>guembeli</u> (Wedekind 1908)

Figs. 6,7: KW 2063; Wunderlich Collection, Enkeberg, Sauerland.

Figs. 9, x1¾; 10,11, x1½: KW 2061; Wunderlich Collection, Wettmarsen (Kante), Sauerland.

<u>Genuclymenia</u> sp.

Fig. 8: KW 2066; Wunderlich Collection, Wäschholz.

<u>Genuclymenia</u> <u>frechi</u> (Wedekind 1908)

Figs. 12,13, x1½: KW 2095; Wunderlich Collection, Beringhausen, Sauerland.

<u>Genuclymenia</u> aff. <u>karpinskii</u> (Perna 1914)

Figs. 14-16, x2: DK 80D 4511.1; Korn Collection, Enkeberg, Sauerland.

Figs. 17,18, x2: MfN; ?Lange Collection, Enkeberg, Sauerland.

PLATE 5.36

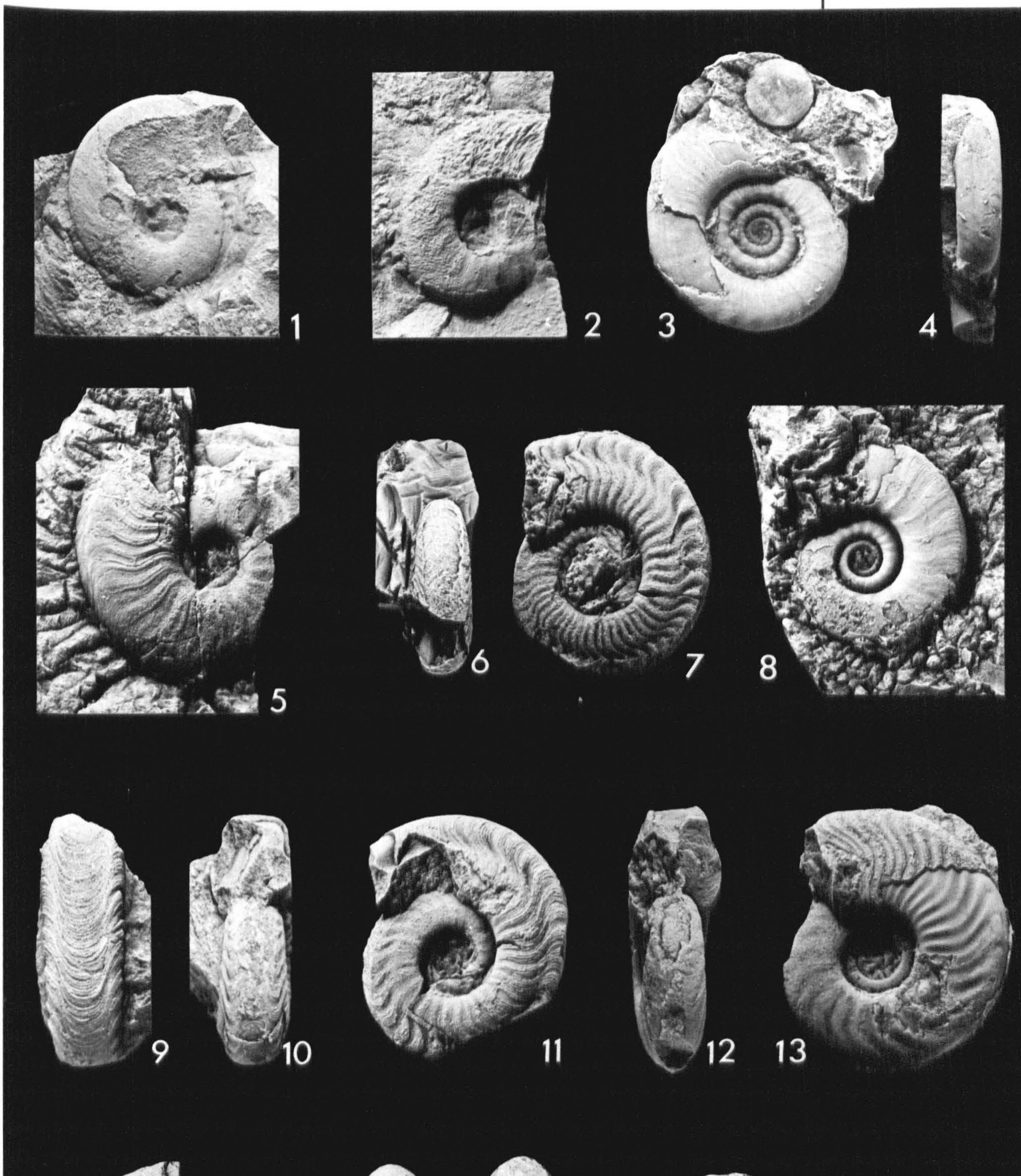

Plate 5.37

All illustrations are natural size unless otherwise indicated.

Cymaclymenia striata (Münster 1832)

Figs. 1; 7-10, x1½: SM H10414; Münster Collection, Schübelhammer, Oberfranken.

Fig. 11: BM 81824; Münster Collection, Schübelhammer, Oberfranken.

Cymaclymenia camerata Schindewolf 1923a

Figs. 2-4, x1½: proposed lectotype, MfN; Schindewolf Collection, Bed 18, Kirch-Gattendorf, Figured by Schindewolf 1923a, pl. XVII, fig. 6.

Figs. 14-16: SM H10415; Münster Collection, Schübelhammer, Oberfranken.

Cymaclymenia sagittalis (Phillips 1841)

Figs. 5,6, x1½: holotype, GSM 7177; Phillips Collection, South Petherwin, Cornwall. Figured by Phillips 1841, pl. LIV, figs. 243a-c.

Cymaclymenia aff. striata (Münster 1832)

Figs. 12, 13: BSP AS VII 545; Münster Collection, Schübelhammer, Oberfranken. Figured by Gümbel 1863, pl. XVIII, figs. 1a-e.

Figs. 17-19, x1½: UEN 92; Münster Collection, Schübelhammer, Oberfranken.

Fig. 20: MfN; Münster Collection, Schübelhammer, Oberfranken.

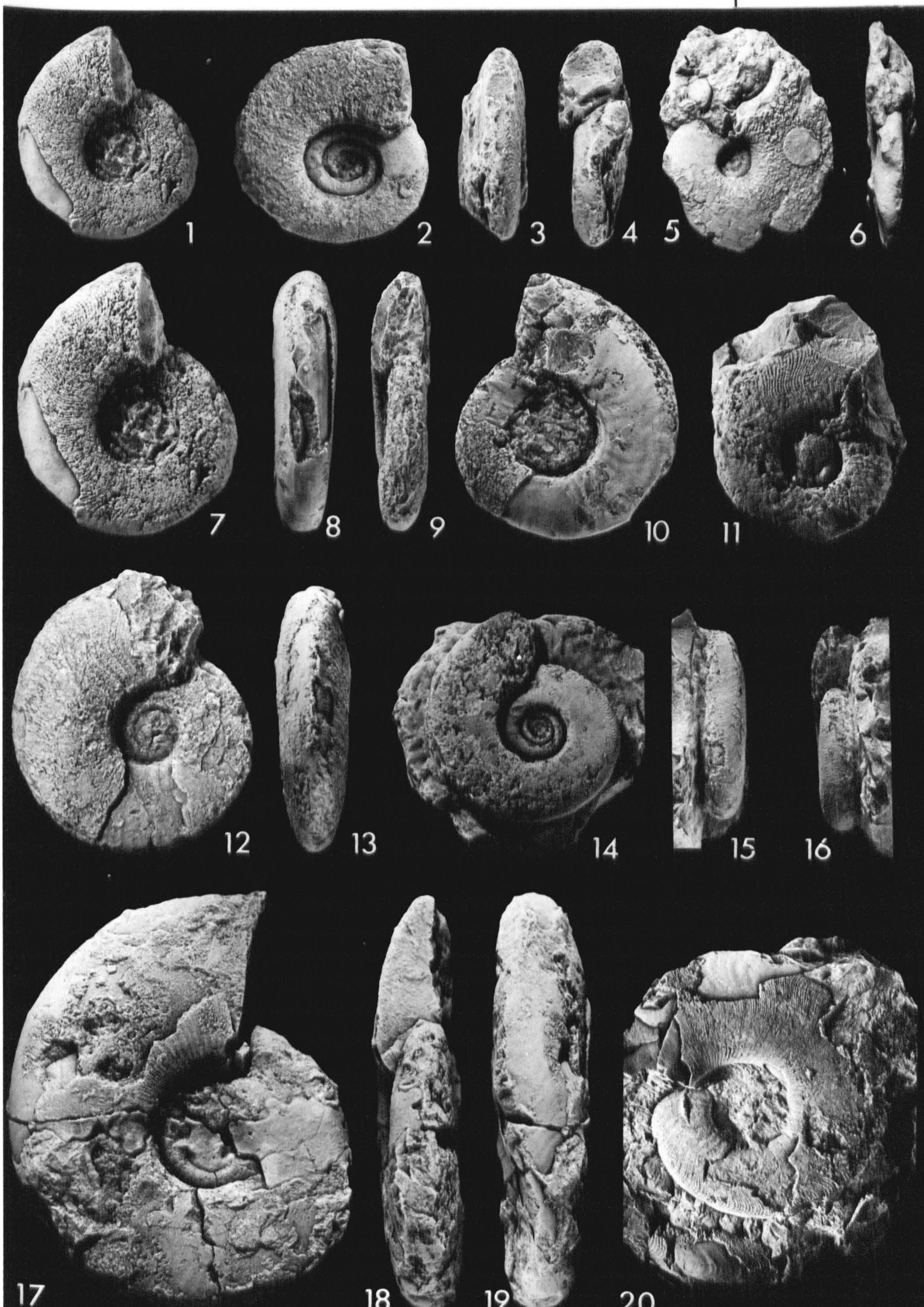
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Plate 5.38

All illustrations are natural size unless otherwise indicated.

Cymaclymenia aff. barbarae (Loewinson-Lessing 1892)

Figs. 1,2; 9, x3: KW 2084; Wunderlich Collection, Reigern.

Cymaclymenia sp.

Fig. 3, x4: HU P82.17; North Africa.

Figs. 4,5, x4: HU P82.18; North Africa.

Figs. 5a,6, x1½: HU P82.19; House Collection, Morocco.

Cymaclymenia involvens Lange 1929

Figs. 7,8, x2: holotype, MfN; Lange Collection, Burg, Balve. Figured by Lange 1929, pl. II, fig. 23.

Fig. 10: paratype, MfN; Lange Collection, Burg, Balve. Figured by Lange 1929, fig. 24.

Cymaclymenia evoluta (Schmidt 1924)

Fig. 10a, x2: lectotype, MfN; Ostprovinzial Steinbruch, Drewer. Figured by Schmidt 1924, pl. 8, fig. 19.

Figs. 12, 13, x1½: MfN; Ostprovinzial Steinbruch, Drewer. Figured by Schmidt 1924, pl. 8, fig. 20.

Cymaclymenia cf. evoluta (Schmidt 1924)

Fig. 11: RE 551 734.5 A371; Paul Collection, Etroeungt β, Scharpenhaus, Heiligenhaus. Figured by Paul 1939, pl. 40, fig. 3.

PLATE 5.38

Plate 5.39

All illustrations are natural size unless otherwise indicated.

Cymaclymenia sp. a

Figs. 1, x4; 7,8, x2: SM H7534; Münster Collection, Schübelhammer, Oberfranken.

Figs. 4-6, x3: HU P82.5; Effenberg, Sauerland.

Cymaclymenia sp.

Fig. 2: BSP; Glass Collection, Kirch-Gattendorf.

Cymaclymenia evoluta (Schmidt 1924)

Fig. 3: RE 551 734.5; Paul Collection, Bed 21, oberer Abschnitt, Ratingen, Cromford. Figured by Paul 1939, pl. 41, fig. 3.

Cymaclymenia semistriata (Münster 1832)

Figs. 9,10, x2: MfN; Münster Collection, Schübelhammer, Oberfranken.

Figs. 12-15, x1½: SM H10416; Münster Collection, Schübelhammer, Oberfranken.

Figs. 18,19, x1½: BSP AS VII 560; Münster Collection, Schübelhammer, Oberfranken. Figured by Münster 1832, pl. III, fig. 4.

Cymaclymenia dorsocostata (Münster 1840)

Figs. 16,17, x1½: lectotype, BSP AS VII 557; Münster Collection, Schübelhammer, Oberfranken. Figured by Münster 1840, pl. XVI, figs. 5a,b.

PLATE 5.39

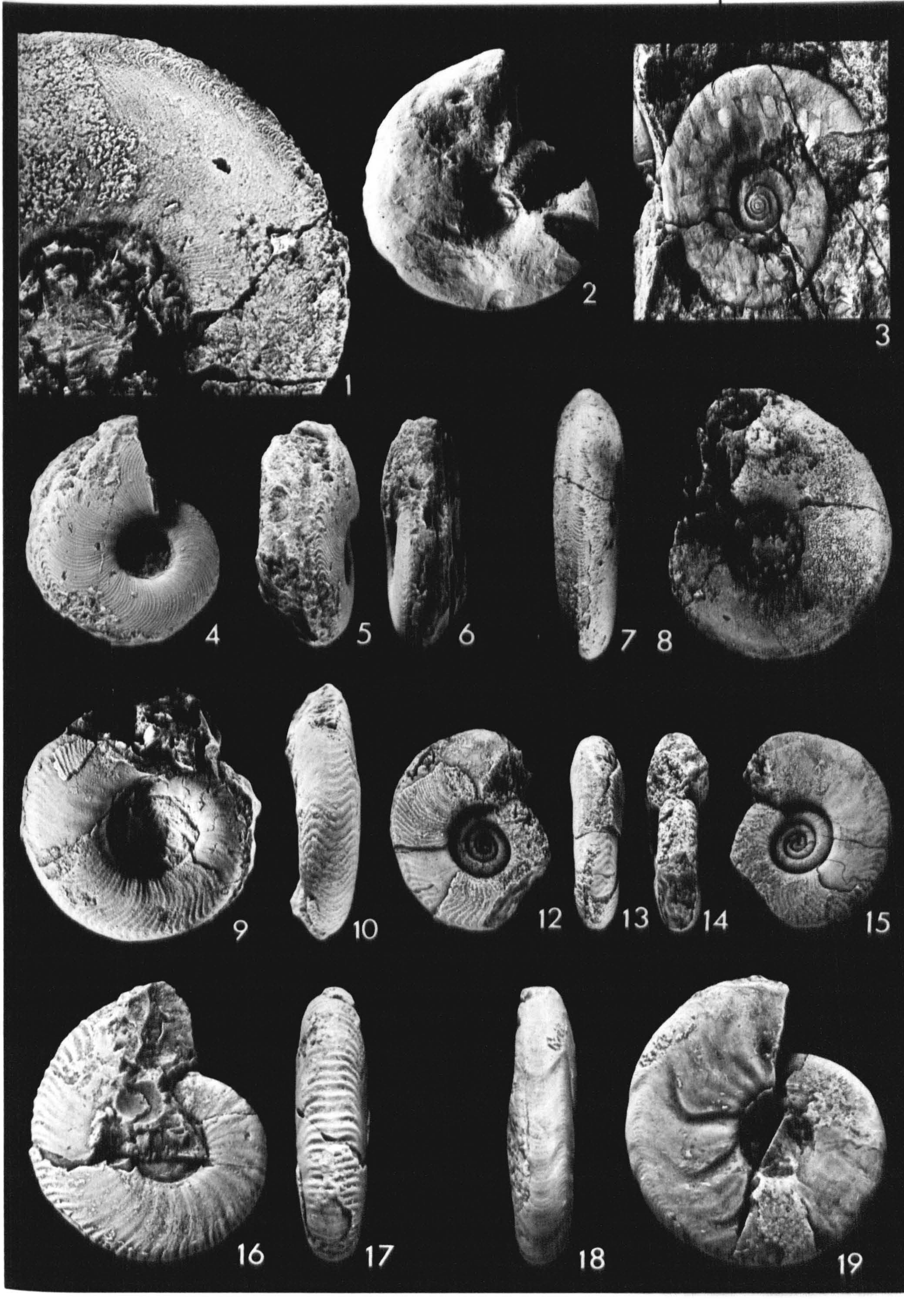

Plate 5.40

All illustrations are natural size unless otherwise indicated.

Cymaclymenia aff. barbarae (Loewinson-Lessing 1892)

Figs. 1,2, x1½: MfN; Lange Collection, Hövel. Figured by Lange 1929, fig. 22.

Cymaclymenia sp.

Figs. 3-5: MfN; Schindewolf Collection, Hauern, Wildungen.

Fig. 10: MfN; Schindewolf Collection, Hauern, Wildungen.

Cymaclymenia aff. serpentina Schmidt 1924

Figs. 6, x2; 7: Denckmann Collection, Langenholthausen. Figured by Schmidt 1924, pl. 7, fig. 2 as Cyma. striata.

Cymaclymenia sp.

Fig. 8, x3: MfN; Schindewolf Collection, Oberrödinghausen, Balve. Figured by Schindewolf 1934, pl. 1, figs. 7a,b.

Cymaclymenia aff. costellata (Münster 1832)

Fig. 9: RE 551 734.5 A131/2; Torley Collection, Hövel. Labelled as Cyma. cordata.

Cymaclymenia costellata (Münster 1832)

Fig. 11: MfN; Denckmann Collection, Wettmarsen, Balve. Figured by Schmidt 1924, pl. 7, fig. 1.

Cymaclymenia aff. barbarae (Loewinson-Lessing 1892)

Figs. 12,13, x2: MfN; Münster Collection, Schübelhammer, Oberfranken.

Cymaclymenia serpentina Schmidt 1924

Figs. 14,15, x2: UEN; ?Münster Collection, ?Schübelhammer, Oberfranken.

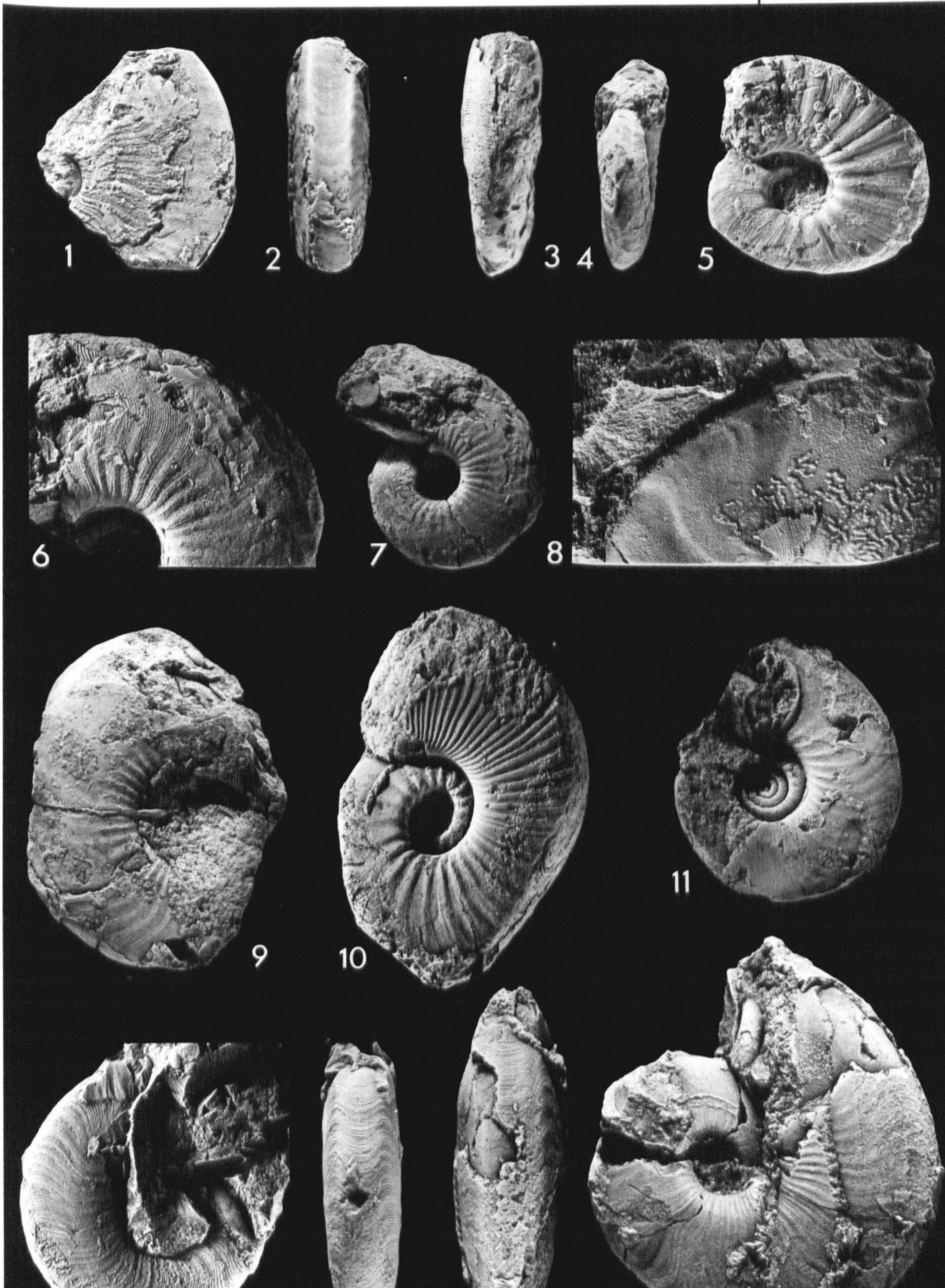
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Plate 5.41

All illustrations are natural size unless otherwise indicated.

<u>Cymaclymenia</u> <u>costellata</u> (Münster 1832)

Figs. 1,2: SM H7530; Münster Collection, Schübelhammer, Oberfranken.

Figs. 7,8,10,11: proposed lectotype, BSP AS VII 546; Münster Collection, Schübelhammer, Oberfranken.

Fig. 9: MfN; von Buch Collection, Dzikowiec, Poland. Figured by Frech 1902, pl. V(IV), fig. 1.

Figs. 12,13, x2: UEN 89; Münster Collection, Schübelhammer, Oberfranken.

<u>Cymaclymenia</u> aff. <u>costellata</u> (Münster 1832)

Figs. 3,4, x1½: SM H7531; Münster Collection, Schübelhammer, Oberfranken.

Figs. 5,6, x2: UEN 88; Münster Collection, Schübelhammer, Oberfranken.

PLATE 5.41

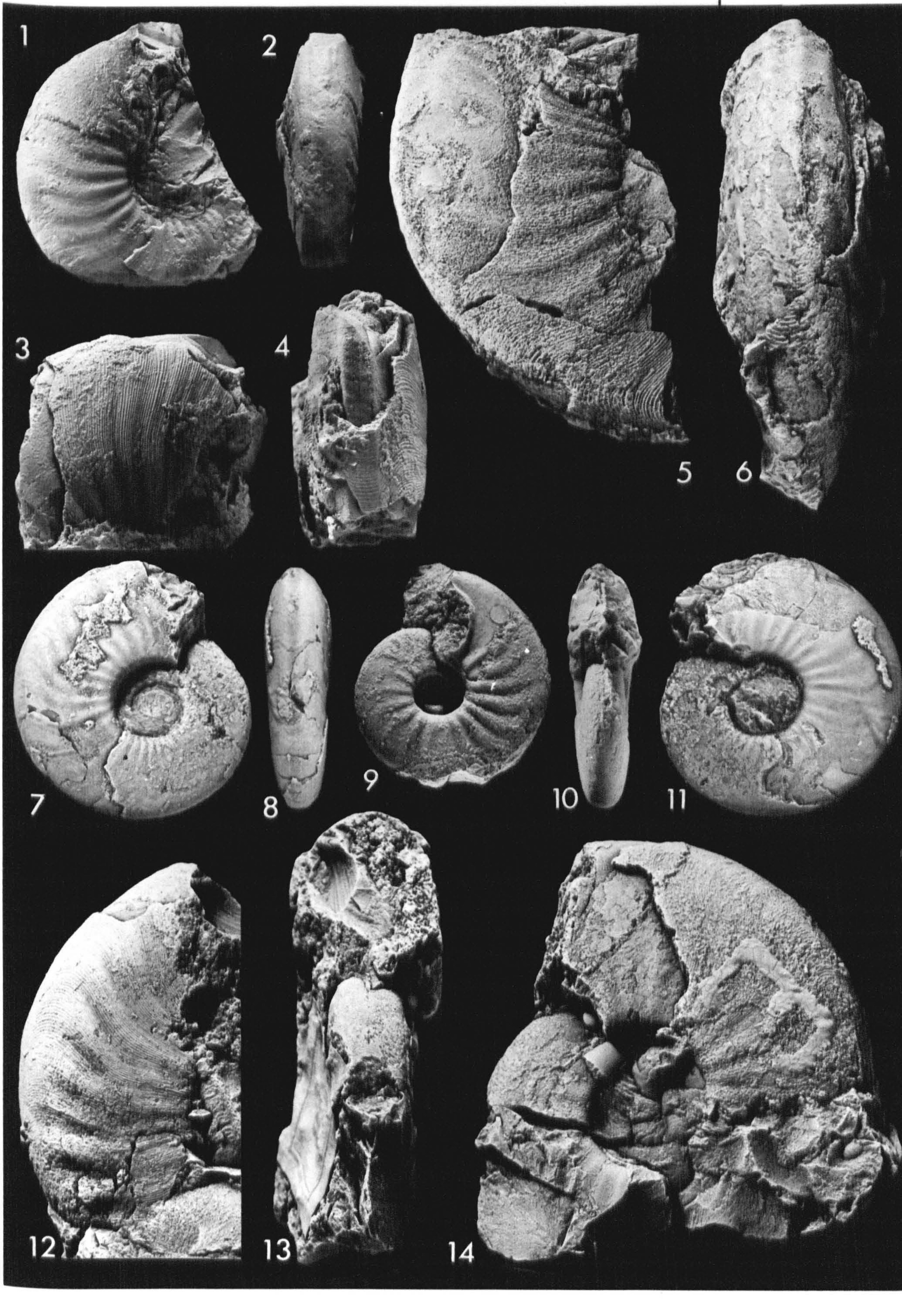


Plate 5.42

All illustrations are natural size unless otherwise indicated.

Cymaclymenia camerata Schindewolf 1923a

Figs. 1, x2; 2, x4: HU P82.20; Steinbruch Köstenhof, Schübelhammer, Oberfranken. This specimen shows three interrupted periods of shell growth, and fracture lines separating them.

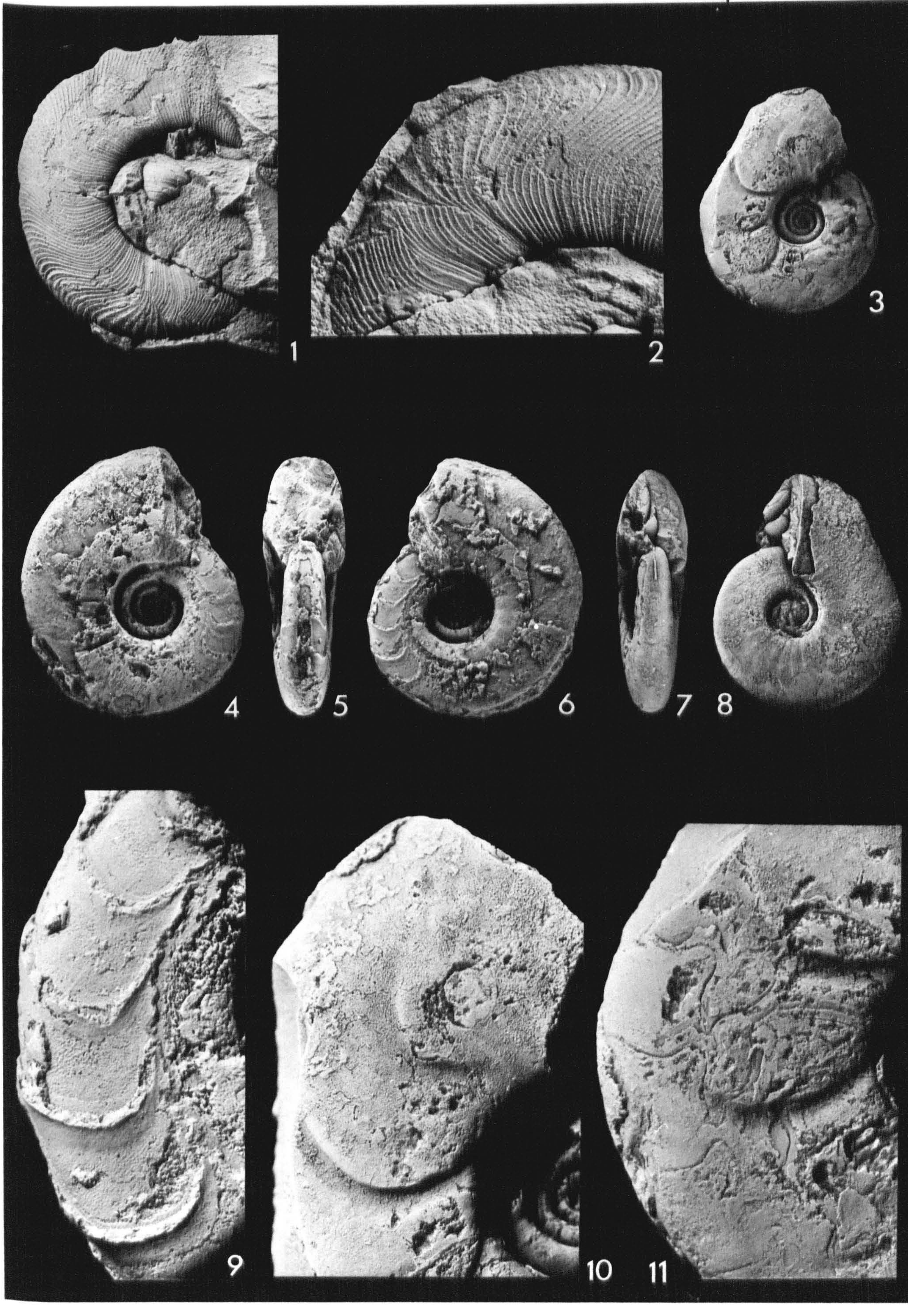
Cymaclymenia sp. b

Figs. 3,7,8: SM H10406; Münster Collection, Schübelhammer, Oberfranken. Fig. 10, x3, is an enlargement of the internal mould of the body chamber, and shows the moulds of sessile arenaceous foraminifera, attached to the internal side of the shell. Fig. 11, x4, shows the suture, and area of attachment of the septum to the shell wall.

Cymaclymenia sp.

Figs. 4-6, x2: SM H10379; Münster Collection, Schübelhammer, Oberfranken. Fig. 9, x8, clearly shows the attachment area of the internal septum, and the dorsal wrinkle-layer.

PLATE 5.42



Chapter 6

The conodont zonation of the Famennian, and its correlation with the ammonoid zonation

Introduction

A conodont zonation of the Famennian, recognised as a possibility by Haas (1947) and Müller and Müller (1957), was established by Helms (1959) and Ziegler (1962), and revised by Ziegler (1971b), and Sandberg and Ziegler (1973); Klapper and Ziegler (1979) have recently published a review. There are only few papers which give details of conodonts and ammonoids collected from the same levels; these enable a correlation of the ammonoid and conodont zonal schemes to be made. Ziegler (1962) described a number of sections in the Rheinische Schiefergebirge: Beuel (Beil), Ball-Berg (Hövel) and Oberrödinghausen in the Sauerland, two trenches at Sessacker near Oberscheld, and quarries at Altes-Tal and Aeketal in the Harz. Further details of Hövel and Oberrödinghausen were given later by Ziegler (1971a).

Glenister and Klapper (1966) found that all of Ziegler's conodont zones were present in the Canning Basin of Western Australia and gave details of co-occurring ammonoids, which were described by Petersen (1975). Buggisch and Clausen (1972) described two sections through the Frasnian-Famennian boundary from Morocco. Eickhoff (1973) discussed the conodont sequence in the railway cutting at Oberrödinghausen, from which Schindewolf (1937a) had described ammonoids. This sequence was proposed as the type section for the Devonian-Carboniferous boundary (Jongmans and Gothan 1937), although this decision maybe in the process of being set aside (Paproth 1980), and other possible stratotypes are currently sought. Brügge (1973) listed ammonoids and conodonts from a section described in detail at Schleiz in Thuringia.

Textfig. 6.1a-c combines all published data for the co-occurrence of Famennian ammonoids and conodonts in western Europe. Some of the information is of limited value; for example Ziegler

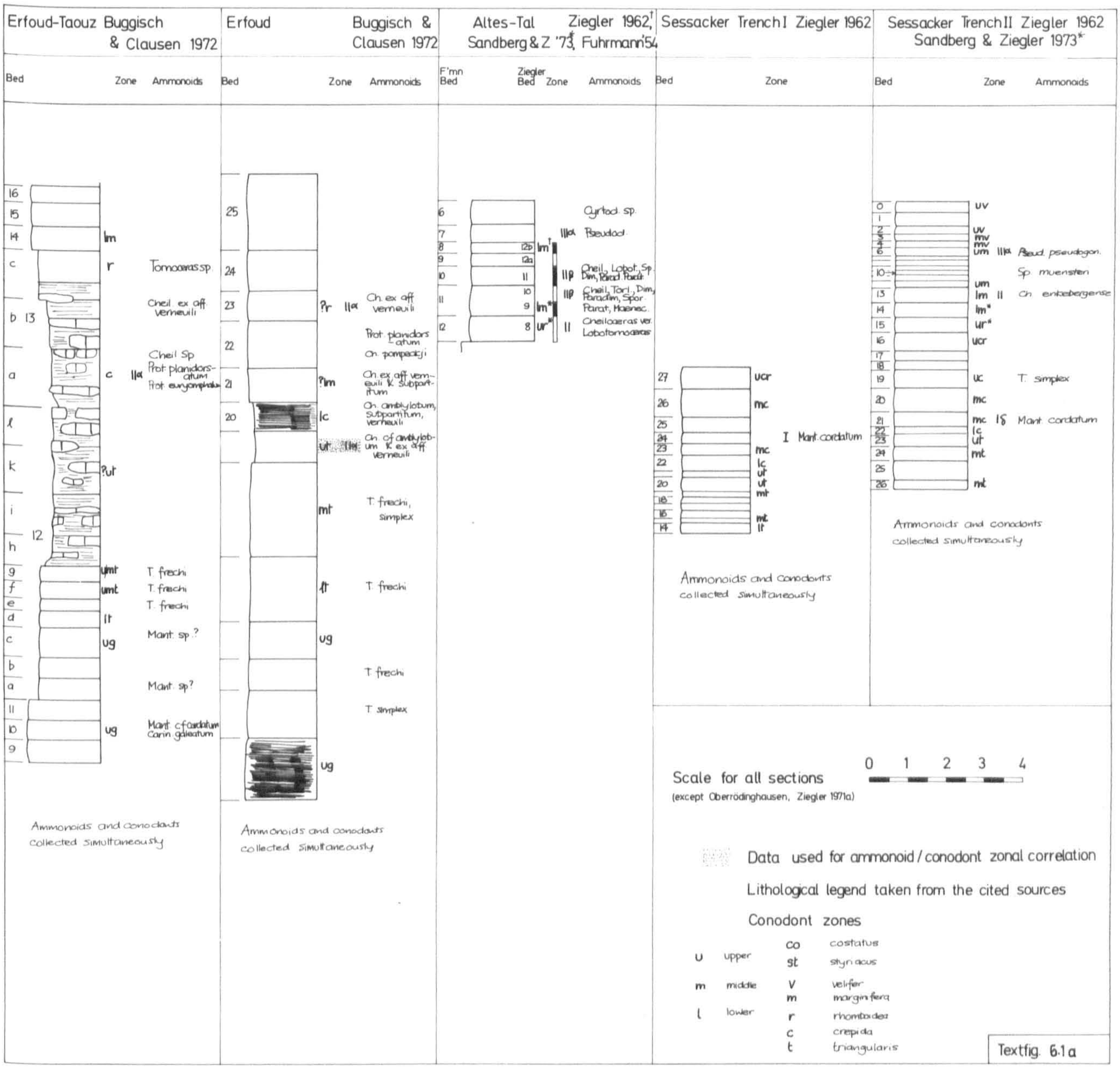
(1962) used some sections with large bed thicknesses, from which ammonoids had previously been described by Born (1912a) and Fuhrmann (1954), in the Harz Mountains, and Schindewolf (1923a) at Kirch-Gattendorf, Oberfranken. Ziegler obtained conodonts from Kirch-Gattendorf simply by dissolving ammonoids which Schindewolf had collected. The sections which Glenister and Klapper (1966) looked at in Australia were far thicker than the Cephalopodenkalk in Germany, but their sampling intervals were large or sporadic.

Attention should therefore only be paid to those few instances where conodonts and ammonoids were either collected from the same sample (stippled ornament in Textfig. 6.1) or there can be no doubt over the sampled horizon. This leaves only four or five levels at which conodont and ammonoid zonal schemes can be directly correlated.

A zone-by-zone account of Famennian conodont correlation is given below. A strict chronological sequence is hindered by the need to discuss the Frasnian/Famennian boundary. This, defined as the base of the Assise de Senzeilles, was long thought to be coincident with the Adorf/Nehden and *Manticoceras*/*Cheiloceras* Stufe boundaries. The latter is defined by the incoming of the simple sutured convex growth-lined *Cheiloceras*, and it was believed that several species of *Manticoceras* continued into the *Cheiloceras* Stufe (House 1979).

Frasnian-Famennian Boundary

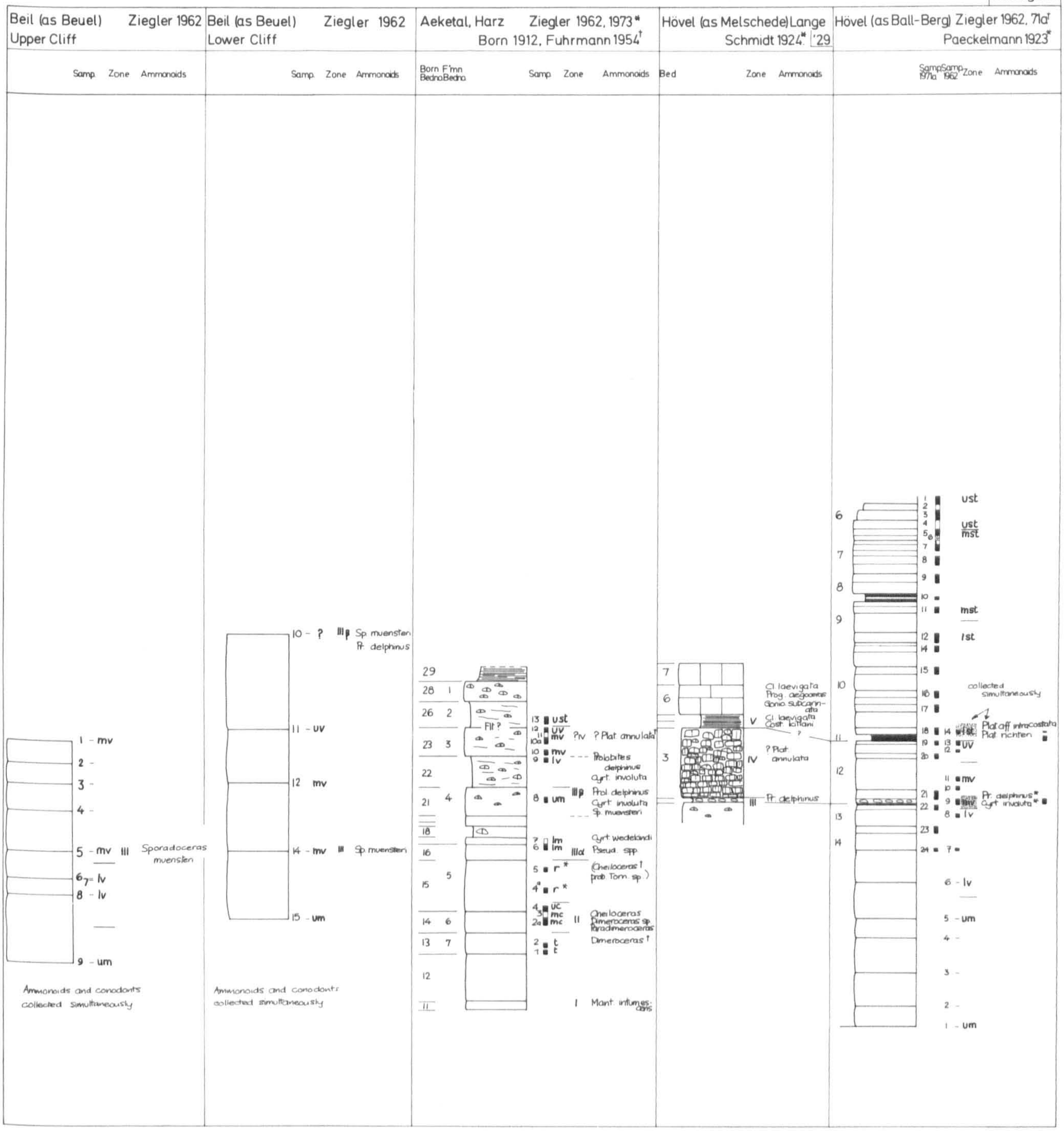
In 1965 Bouckaert, Ziegler and Thorez recognised the Middle *triangularis* Zone at the base of the Famennian at its type section of Senzeilles. By correlation with (uncited) ammonoid evidence from this zone in the Rheinische Schiefergebirge they stated that the uppermost part of the *Manticoceras* Stufe overlapped with the Famennian, and thus, by implication, the base of the *Cheiloceras*



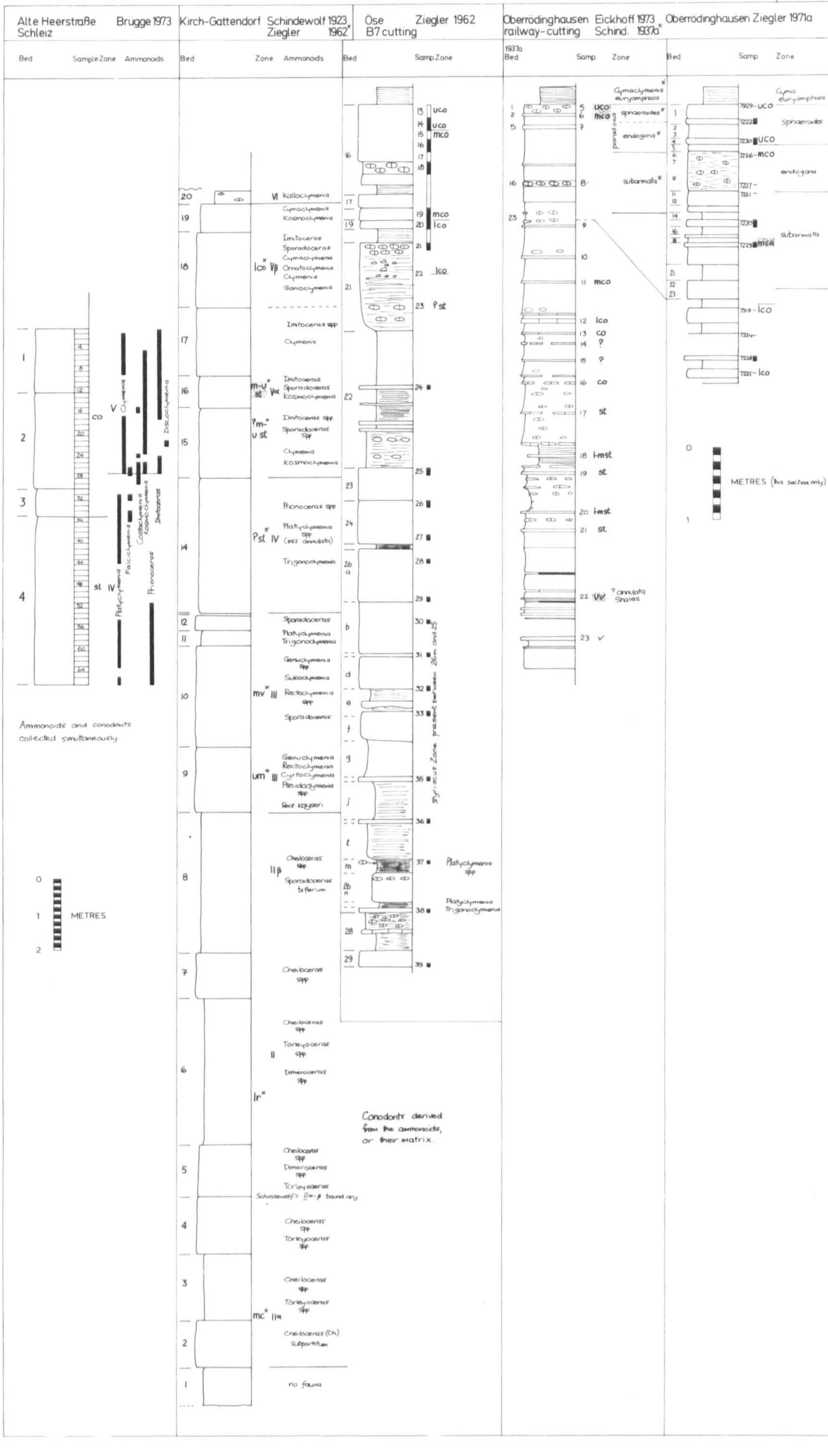
Erfoud-Taouz Buggisch & Clausen 1972
Erfoud Buggisch & Clausen 1972
Altes-Tal Ziegler 1962,† Sandberg & Z '73,* Fuhrmann'54
Sessacker Trench I Ziegler 1962
Sessacker Trench II Ziegler 1962 Sandberg & Ziegler 1973*
Bed
Zone
Ammonoids
F'mn Bed
Ziegler Bed
Tornoceras sp.
Cheil. ex aff. verneuili
Cheil. Sp.
Prot. planidorsatum
Prot. euryomphalum
T. frechi
Mant. sp.?
Mant. cf. cordatum
Carin. galeatum
Ch. ex aff. verneuili
Prot. planidorsatum
Ch. pompeckji
Ch. ex aff. verneuili & subpartitum
Ch. amblylobum, subpartitum, verneuili
T. frechi, simplex
T. simplex
Cyrtocl. sp.
Pseudocl.
Cheiloceras verneuili
Lobotornoceras
I Mant. cordatum
Pseud. pseudogon.
Sp. muensteri
Ch. enkebergense
T. simplex
Mant. cordatum
Ammonoids and conodonts collected simultaneously
Scale for all sections
0 1 2 3 4
(except Oberrödinghausen, Ziegler 1971a)
Data used for ammonoid / conodont zonal correlation
Lithological legend taken from the cited sources
Conodont zones
u upper
m middle
l lower
co costatus
st styriacus
v velifer
m marginifera
r rhomboidea
c crepida
t triangularis

Textfig. 6.1a

Textfig. 6.1b



Beil (as Beuel) Ziegler 1962
Upper Cliff
Beil (as Beuel) Ziegler 1962
Lower Cliff
Aeketal, Harz Ziegler 1962, 1973*
Born 1912, Fuhrmann 1954†
Hövel (as Melschede) Lange
Schmidt 1924* '29
Hövel (as Ball-Berg) Ziegler 1962, 71a†
Paeckelmann 1923*
Samp. Zone Ammonoids
Bed
Sporadoceras muensteri
Sp. muensteri
Pr. delphinus
Ammonoids and conodonts collected simultaneously
collected simultaneously



Alte Heerstraße Schleiz
Brügge 1973
Bed
Sample Zone Ammonoids
Kirch-Gattendorf Schindewolf 1923, Ziegler 1962*
Bed
Zone Ammonoids
Öse B7 cutting
Ziegler 1962
Bed
Samp Zone
Oberrödinghausen railway-cutting
Eickhoff 1973 Schind. 1937a*
Oberrödinghausen Ziegler 1971a
Ammonoids and conodonts collected simultaneously
METRES
Conodonts derived from the ammonoids, or their matrix.
METRES (this section only)

Stufe and of the Famennian could no longer be considered as synonymous.

Later studies of the conodont faunas around the Frasnian-Famennian boundary (Bouckaert, Mouravieff, Streel, Thorez and Ziegler 1972, Streel _et al_. 1977) showed there to be a faunal break at the base of the _triangularis_ Zone in many sections throughout eastern Belgium. Generally the succession representing the lower _triangularis_ Zone is thin or absent. The base of the _triangularis_ Zone was formally suggested (Streel _et al_. 1977) as the base of the Famennian, at Bed 48bis in the Hony railway cutting south of Liège. This level could not be recognised at Senzeilles, where Gosselet (1897) had drawn the Frasnian-Famennian boundary, but a palynological study suggested that it lay in Bed 31 between the appearance of _Pampoecilorhynchus lecomptei_ (Sartenaer) and the appearance of Middle _triangularis_ Zone conodonts, which had been considered as synchronous events by Bouckaert _et al_. (1965). This is a level above the Frasnian-Famennian boundary of Gosselet, but using the conodont evidence, either boundary falls within the _Manticoceras_ Stufe, since they are below the Upper _triangularis_ Zone, in which is the earliest reported occurrence of _Cheiloceras_ (Buggisch and Clausen 1972).

triangularis Zone

The early work of Ziegler (1962) produced imprecise evidence of the ammonoid faunas of this Zone. From 60cms. of limestone at Aeketal (Beds 6,7 of Fuhrmann 1954) Ziegler collected conodonts ranging in age from the _triangularis_ to Upper _crepida_ Zones.

These levels had yielded no _in situ_ fauna to Fuhrmann, but he did find in loose blocks _Dimeroceras_, _Sporadoceras_ and _Protornoceras_, which he assigned to the upper horizon, Bed 6, and _Dimeroceras_ which he assigned to Bed 7. Ziegler wrongly interpreted these as representing faunas from I - IIα. More detailed information can be found in Born (1912a) who used thinner stratigraphic units. He recorded Cheiloceras, Dimeroceras and Paradimeroceras from his Bed 14 (= Bed 6 of Ziegler and Fuhrmann); these are found in either IIα or possibly IIβ, and this would be in accord with Ziegler's record of a Middle crepida Zone fauna. Born found no ammonoids in the underlying Bed 13, which Ziegler dated as triangularis Zone. With hindsight, and regard to the way in which Fuhrmann collected his material, it is reasonable to assume that he was mistaken in believing that he had collected Dimeroceras from this horizon. Therefore Ziegler (1962) had no evidence concerning the ammonoids of the triangularis Zone.

The first suggestion of Cheiloceras Stufe ammonoids occurring together with triangularis Zone conodonts, in the same sample, was provided by Glenister and Klapper (1966). From a sample numbered UWA 26213 (table 8; = Bed T45 C62 of Petersen 1975) Cheiloceras ovatum was collected with a conodont fauna dated as ranging from the Upper triangularis to lower crepida Zones.

In 1971(b) Ziegler stated that the Middle and Upper triangularis Zones were associated with Manticoceras cordatum (without citing precise evidence), which meant that these zones should be included within the Manticoceras Stufe. Using Glenister and Klapper's (1966) evidence the Lower crepida Zone was placed in the Cheiloceras Stufe. Crickites holzapfeli, the index for the highest, Iδ zone of the Manticoceras Stufe had not been obtained from the Middle or Upper triangularis Zones and so Ziegler created a new ammonoid zone termed post Iδ, with Manticoceras, but lacking Crickites or Cheiloceras.

House (1962) reported a Iδ fauna from the Hanover Shale, the upper part of which Klapper, Sandberg, Collinson, Huddle, Orr, Rickard, Schumacher, Seddan and Uyeno (1971) correlated with the Upper triangularis Zone (see also House and Kirchgasser 1981).

More positive evidence of ammonoids and conodonts from the triangularis Zone was provided by Buggisch and Clausen (1972), who recognised the co-occurrence in Morocco at Erfoud-Tafilalt of Palmatolepis minuta minuta (Branson and Mehl), Pa. cf. regularis Cooper, Ch. (Ch.) ex aff. verneuili and Ch. (Ch.) cf. amblylobum in all but the lowermost part of the Upper triangularis Zone.

Buggisch and Clausen extensively review all published biostratigraphic data available from around the Frasnian/Famennian boundary. Ziegler confirmed to them (Buggisch and Clausen 1972, p. 158, footnote 3) that he had collected Mant. cordatum from the Middle crepida Zone. They had found only Cheiloceras at that level and explained this unexpectedly late occurrence of Manticoceras as an "echte phylogenetische Nachlaufer".

Prior to the publication of this Moroccan data Ziegler (1962, 1971b) had considered the Manticoceras Stufe to extend to the base of the crepida Zone. In the light of Buggisch and Clausen's data from Morocco Ziegler (1979) revised the post Iδ interval to include only the Middle and lowermost Upper triangularis Zones. House (1973, 1979) discussed the inadvisability of using the absence of a taxon, in this case Crickites holzapfel, the index for Iδ, to define a zone, but he introduced a new zone of "Manticoceras sp." instead (House 1975).

Ziegler has made use of the absence of taxa to define other subzones; for example the Upper marginifera and Upper costatus divisions. This practice did not seem sensible to Dreesen (1977, p. 514) who did not recognise the Upper marginifera Zone.

crepida Zone

Ziegler (1962) discussed *crepida* Zone faunas from a number of localities. He dug two trenches at Sessacker, in the Rheinische Schiefergebirge. In Bed 24 of Trench I *Manticoceras cordatum* was associated with a Middle *crepida* Zone fauna, and the base of the *Cheiloceras* Stufe was considered to be in Bed 26, also in the Middle *crepida* Zone, where *Drevermannia* (*Formonia*) *formosa* was found. Trench II yielded more ammonoids; Bed 21 contained *Manticoceras cordatum*, *Tornoceras simplex* and a Middle *crepida* Zone fauna. No cheiloceratacean were obtained until much higher in the sequence (Bed 13).

Contradictory data was obtained from other sections. Ziegler (1962) found a Middle *crepida* Zone fauna from Beds 2 and 3 at Kirch-Gattendorf, from which a number of species of *Cheiloceras* had already been described by Schindewolf (1923a). These were *Cheiloceras subpartitum*, *verneuili*, *circumflexum*, *amblylobum*, and *Torleyoceras oxyacantha* and *curvispina*. The ammonoid faunas of Beds 6 and 7 at Aeketal, Harz (Ziegler's samples 1,2 (*triangularis* Zone) 2a,3 (Middle *crepida* Zone) 4 (Upper *crepida* Subzone)) have already been discussed. The most cautious interpretation from these three localities is that the Middle *crepida* Zone encompasses ammonoid zones ranging from Iδ to IIβ, or that the range of *Manticoceras* extends upwards to the Middle *crepida* Zone.

From the lowest part of the road section at Oberrödinghausen Ziegler (1962, p. 144) reported *Cheiloceras circumflexum*, together with a conodont fauna which he placed in the Upper *crepida* Zone.

It would be useful at this point to discuss direct and indirect evidence of *Manticoceras* occurring in the *crepida* Zone, and hence the *Cheiloceras* Stufe.

Indirect evidence relates to three species: *M. superstes*

(Wedekind), recorded by Wedekind (1908) using a single museum specimen from the Nehden, and by Schindewolf (1923a) from a single specimen from Bed 3 at Kirch-Gattendorf; M. niedzwieski (Dybcynski) described together with a fauna of Cheiloceras and tornoceratids, and M. nehdense Lange, established (1929) for a single specimen from the Nehden Schiefer at Nehden. Clausen (1969) referred this latter species to Lobotornoceras and two specimens were briefly described by Jux and Krath (1974). Whilst their generic assignment is not necessarily correct (see Chapter 3) nehdense Lange certainly belongs in the Tornoceratidae, rather than the Gephuroceratidae. The same can be said for the other two species under discussion, and they may all be conspecific, but the ontogeny of none of these species has been described. Bogoslovskiy (1969) treated all three species as Manticoceras and House (1979) included the German examples in Manticoceras.

Thus the only acceptable record of Manticoceras from the Cheiloceras Stufe is from Ziegler's two trenches at Sessacker (Ziegler 1962) which was reiterated in Buggisch and Clausen (1972) (see above). There are three ways in which its presence can be explained: firstly it may truly be a very rare element in the fauna, and thus difficult to collect, it may simply have been misidentified, or it could have been reworked into higher levels. Ziegler's certainty about the occurrence of M. cordatum must discount the possibility of collecting error. Two of the possibilities are easily dismissed. I have not seen the specimens in question to confirm their identity, but M. cordatum, if well preserved, is unlikely to have been mistakenly identified because of its distinctive subevolute shell-form and suture. No mention was made by Ziegler of reworking the associated conodont faunas, so it is unlikely that M. cordatum was reworked into higher levels. This leaves only the possibility that M. cordatum was truly a very rare element in the fauna, however, no other collection from the Middle crepida Zone has reported it (see Wedekind 1908, Born 1912a, Sobolev 1914a, Schmidt 1921, Schindewolf 1923a, Lange 1929, Nalivkina 1936b, Glenister and Klapper 1966, Petersen 1975, and this thesis).

Glenister and Klapper (1966) reported a number of co-occurrences of goniatites and conodonts in the crepida Zone (Textfig. 6.2). The reported occurrence of Sporadoceras in samples B55 and 56 is ignored by Glenister and Klapper (1966, p. 838), and Petersen (1975, p. 50) explains it as due to laboratory "admixture" of specimens. Also Ch. (Ch.) ovatum is not recorded in Petersen's Table 2 as occurring in WAPET B132-1 4 yet the caption to Petersen's (1975) textfig. 15 gives such a provenance to two specimens. This horizon is not mentioned in the systematic description of the species. Tornoceras simplex was probably referred as Ch. circumflexum by Glenister and Klapper.

Their data confirm that the Lower and Middle crepida Zones are equivalent to IIα of the ammonoid scheme. But it also suggests that there are already indications in the Upper crepida Zone of IIβ with Sp. (Sp.) biferum (UWA 26189) and ?Dimeroceras sp. (WAPET 154-76).

Not all of the information listed above was repeated or confirmed by Petersen (1975), who studied the ammonoids used to date the sequences, and acknowledged (p. 50) difficulties in interpreting the section known as T41, collected from by Teichert in 1939.

Buggisch and Clausen (1972) recorded Ch. (Ch.) verneuili, Ch. (Ch.) subpartitim, Ch. (Ch.) pompeckji (?), Ch. (Ch.) circumflexum and Ch. (Ch.) amblylobum from a section yielding crepida Zone (s.1) conodonts at Erfoud. Another section at Erfoud-Taouz, also yielded Ch. (Ch.) ex. aff. verneuili together with Protornoceras euryomphalum and Prot. planidorsatum, from the same conodont Zone.

Sample	*Tornoceras simplex*	*Cheiloceras (Ch.) circumflexum*	*Ch. (Torleyoceras) sacculum*	*Ch. (Ch.) ovatum*	*Cheiloceras* indet.	*Ch. (Torl.)* sp.	*Sporadoceras (Sp.) biferum*	*Sp. (Sp.) latilobum*	*Paratornoceras lentiforme*	*Dimeroceras bredelarense*	Ammonoid zone (where assignable)	Conodont Zones, (from Glenister and Klapper 1966).	
T41 B53									x	x	IIα-β		
B52 =UWA26189	x											U. crepida	table 7
B54	x		x								IIα		
B55			x		x			x			(IIβ)		
B56 =UWA26196	x		x				x				(IIβ)	L. crepida	
B57 =UWA26197				x							IIα		
B58	x												
T45 C62 =UWA26213				x							IIα	U. triangularis - L. crepida	table 8
B132-54	x					x						M. triangularis - L. crepida	table 2
B176-98	x											U. crepida	
UWA26189							2				(IIβ)		7
B132-54	3	3				5					IIα		
B154-76	2									1	IIα		2
GSWA1027A7		3									IIα		1
1027A9			2								IIα		
K260				12							IIα		
UWA26197				14									

Textfig. 6.2 Ammonoid faunas from Western Australia dated by conodonts after Glenister and Klapper 1966, and Petersen 1975. Dates in brackets were ignored by the authors, explained as caused by "laboratory admixture" (Petersen 1975).

rhomboidea Zone

This zone, established by Ziegler in 1962, was divided by Sandberg and Ziegler (1973), who inserted a Lower division with Pa. poolei, and restricted the former rhomboidea Zone, without Pa. poolei, to a new Upper division. There are few reports of ammonoids dated as from this zone. Schindewolf's (1923a) Beds 5-6, which contained Cheiloceras spp., Torleyoceras, Dimeroceras and possibly Sporadoceras also (the records are uncertain), were dated by Ziegler (1962) as Upper rhomboidea Zone (lower part). Bed 12 at Altestal (Fuhrmann 1954), dated as Upper rhomboidea Zone (Ziegler 1971a, Sandberg and Ziegler 1973), contained species of Cheiloceras and Lobotornoceras. Both samples may be IIα or IIβ in age.

A number of samples (GSWA 1028, B31 C1-5, BMR K177, UWA 26162 (= T39 B8), UWA 26946c (= Tc)) were reported, Glenister and Klapper (1966). These contained Cheiloceras, Paratornoceras, Dimeroceras and can be dated as either IIα or β.

Kasig, Dreesen and Bouckaert (1979) described a number of profiles through the Famennian of the Aachen area. They detailed four sections from which conodonts were collected, and all included a nodular limestone horizon at most 4m thick. Schindewolf (1921) listed a fauna from this level, including Ch. amblylobum, verneuili, circumflexum, subpartitim and Torleyoceras globosum, sacculum. This fauna certainly belongs to II, but since the occurrence of Sporadoceras is needed to recognise IIβ the level is most likely to be IIα. Their results are not set out so as to identify the age of each of their conodont samples, but at least one sample from the Cheiloceraskalk, Ha3, with Pa. rhomboidea and Pa. cf. poolei, seems to belong to the Lower rhomboidea Zone.

Bouckaert, Streel and Thorez (1968) placed the base of the

Upper Famennian (Fa2) at the base of the rhomboidea Zone thus including only two of the 13 Famennian ammonoid zones in the Lower Famennian.

In conclusion the rhomboidea Zone can be correlated with the upper part of IIα and probably with IIβ.

marginifera Zone

This zone, established by Ziegler (1962) as the quadrantinodosa Zone, was renamed as the marginifera Zone by Sandberg and Ziegler (1973). There is an Upper and Lower division.

At Sessacker in Trench II Ziegler (1962) recorded Cheiloceras enkebergense from the Lower marginifera Zone (i.e. IIβ), and Sp. (Sp.) muensteri and Ps.pseudogoniatites and Pn. weissi from the Upper marginifera Zone (i.e. IIIα).

A more prolific ammonoid fauna was obtained from Altestal where Sandberg and Ziegler (1973) recognised the Lower marginifera Zone in Beds 11-8 of Fuhrmann's (1954) sequence. Bed 11 was dated as IIβ by Fuhrmann and contained Cheiloceras, Torleyoceras, Paratornoceras, Dimeroceras, Sporadoceras and Maeneceras; Bed 10, dated as IIγ (but without explanation; it is better regarded as IIβ) contained Cheiloceras, Paratornoceras, Dimeroceras, Sporadoceras and Maeneceras. Above this is Beds 7 and 6 Pseudoclymenia and then Cyrtoclymenia appeared, but Ziegler was unable to obtain conodonts from these levels. The upper part of this section, above a fault (see Fuhrmann 1954, fig. 3, and Ziegler 1971a, fig. 18) has been subject to different interpretations. Ziegler found rhomboidea Zone conodonts (i.e. IIα-β) where Fuhrmann (Bed 2) had reported Cyrtoclymenia and Prionoceras (i.e. IIIβ).

The Aeketal section was sampled in greater detail by Ziegler than by Fuhrmann. Thus in Bed 5, to which Fuhrmann assigned a

IIIα age, Ziegler found a series of conodont zones from Upper crepida to Lower marginifera Zones (samples 4-6). However, if we use the more precise information contained in Born (1912a) the upper 24cms of Bed 5 (= Ziegler's sample 6, Lower marginifera Zone) can be interpreted as containing Rect. kayseri and Ps. pseudogoniatites (IIIα or β) and the lower 10cms of Bed 4 (= Ziegler's sample 7, Lower marginifera Zone) as containing Cyrt. wedekindi (hence IIIβ).

Ziegler found only the Upper marginifera Zone at Kirch-Gattendorf, in Bed 9, where Schindewolf reported Genuclymenia, Pseudoclymenia, Rectoclymenia and Cyrtoclymenia, which may be IIIα, but is more likely to be IIIβ, (see Chapter 3).

Glenister and Klapper (1966) reported nine instances of co-occurrence of ammonoids and marginifera Zone conodonts, but in only one case (WAPET GI A1, (Table 5)) is there an ammonoid specimen whose age can be estimated, and this, a Cyrtoclymenia (therefore IIIα or more probably IIIβ; but see above), was not described by Petersen (1975).

In conclusion there is evidence at Altestal that the Lower marginifera Zone occurs in IIβ, recognised by the presence of Sporadoceras and absence of Pseudoclymenia, and Cheiloceras. The Lower marginifera Zone at Aeketal also occurs with Pseudoclymenia Cyrtoclymenia and Rectoclymenia, indicative of IIIα or β. However, at Kirch-Gattendorf these three genera occur with an Upper marginifera Zone fauna. At Sessacker the Lower marginifera Zone is associated with a IIβ fauna, and the Upper marginifera Zone with a IIIα fauna.

velifer Zone

This was established by Ziegler (1962) and divided into three parts.

At Aeketal detailed sampling by Ziegler (1962) identified the three divisions of this zone from Fuhrmann's (1954) Bed 3, in which he had found Plat. annulata and Rect. roemeri (hence IV). At Hövel Ziegler's sample 9, with a Middle velifer Zone fauna, came from a level from which Paeckelmann (1924) had reported Cyrt. involuta and Prolobites delphinus, hence IIIβ or IV.

Two outcrops at Beil (Beuel) were examined by Ziegler (1962) and these yielded a few cephalopods. From the upper cliff in the Middle velifer Zone, sample 5 also yielded Sp. (Sp.) clarkei and Sp. (Sp.) muensteri, which occur as low as IIIβ. The latter also recurred in sample 14 from the lower cliff, in the Middle velifer Zone. Prolobites, but no conodonts, were found in sample 10, which came from 1.40m above sample 11, in the Upper velifer Zone.

The velifer Zone at Kirch-Gattendorf spanned a thick sequence, from Beds 10 to 13. Here Schindewolf had failed to find Prolobites and had drawn an arbitrary base to IIIβ. Bed 10 (Middle velifer Zone) contained Sporadoceras, Rectoclymenia, Cyrtoclymenia Sulcoclymenia and Genuclymenia. Bed 11 (also Middle velifer Zone) contained these genera, plus Platyclymenia.

The Lower velifer Zone was not recognised, and Bed 13, from which Ziegler isolated an Upper velifer Zone fauna, contained no cephalopods.

The evidence of Aeketal suggests that the velifer Zone already contains an annulata Zone ammonoid fauna (i.e. IV), but that the Middle velifer Zone has a IIIβ fauna.

styriacus Zone

This zone, divided into three parts, has remained unchanged since Ziegler extablished it in 1962. It is the conodont zone from which fewest ammonoids have been reported.

At Hövel the styriacus Zone lay at the top of Ziegler's section (1962), and he correlated it with a level recognised by Paeckelmann as the base of Vα. Later (1971a) Ziegler obtained a Lower styriacus Zone fauna together with Plat. aff. intracostata (hence IV) from the same level (1962: sample 14) which sheds some doubt on his earlier correlation.

Elsewhere in the Rheinische Schiefergebirge a styriacus Zone fauna was recognised only at Oese where two black shale horizons (Bed 26 o and m) were considered by Schmidt (in Ziegler 1962) to contain numerous species of Platyclymenia. However, at this section some 16 samples lacked useful conodonts, and the one sample (sample 33) to which a styriacus Zone could be assigned lay some 5 metres above the upper shale in which Platyclymenia had been determined.

The evidence from Kirch-Gattendorf was no clearer. Bed 14, from which Schindewolf had collected numerous Prionoceras and Platyclymenia, was only questionably assigned by Ziegler to the Lower styriacus Zone. The styriacus Zone here continued up into Beds 15 and 16, comprising the Lower Clymenia Stufe, with Clymenia, Imitoceras and Kosmoclymenia.

Brügge (1973) also recorded Platyclymenia and Prionoceras in the styriacus Zone, together with Falciclymenia.

Glenister and Klapper (1966) reported only one sample from the styriacus Zone, and this may also have ranged into the costatus Zone. Associated with it were Cyrtoclymenia, Pleuroclymenia, Raymondiceras and Protoxyclymenia.

Helms (reported in Ziegler 1971b) reported that the Middle styriacus Zone lay in IV, and that the IV-V boundary lay within the Upper styriacus Zone. Presumably he was referring to information later published by Brügge (1973, see below), which gave slightly different results. Ziegler had earlier (1962) placed the upper limit of IV in the lower styriacus Zone, but modified this in (1971b) stating that new uncited evidence showed that IV comprised part of the Upper velifer, and most of the Lower styriacus Zones, but didn't state which specific sections demonstrated this. Furthermore Ziegler (1971a) stated that the Middle styriacus Zone had already ("1962") been shown by him to be clearly associated with "gonioclymenid ammonoids", indicative of V. I can find no such reference.

It seems that the annulata Zone extends into the Lower styriacus Zone, and that the Clymenia Stufe (V) begins in the upper styriacus Zone.

costatus Zone

This, the highest of the wholly Famennian conodont zones, was established by Ziegler in 1962, with three divisions. Only the lowermost was collected from samples also yielding cephalopods, and these indicated a Vβ age.

The goniatites and clymeniids of the Wocklumeria Stufe had been described in great detail by Schindewolf (1937a) from the railway cutting at Oberrödinghausen. Ziegler (1962) made use of a newly excavated road cutting nearby to detail a sequence ranging throughout the whole of the Famennian. Few ammonoids were recorded in Ziegler's description, and unfortunately a revision of the Wocklumeria Stufe cephalopod faunas by Thiem (see Ziegler 1962, p. 145, footnote 23) was never published. The two authors attempted to correlate precisely the railway and road sections, but without success.

Later Ziegler (1971a) published results of collecting from the railway-cutting, and placed the Middle/Upper costatus Zone boundary at the base of Schindewolf's Bed 7, in the Kamptoclymenia endogona Subzone. The Lower/Middle costatus Zone boundary was placed less certainly at the base of Schindewolf's section, which was, by implication (Schindewolf 1937a) at the boundary between the Clymenia and Wocklumeria Stufe. This boundary is poorly defined in terms of ammonoid species ranges.

Eickhoff (1973) studied the 28m thick railway-cutting sequence at Oberrödinghausen in its entirety. He considered that the Middle costatus Zone was represented by a much greater thickness of strata than stated by Ziegler. He restricted the Upper costatus Zone to Schindewolf's Bed 1, that is the uppermost part of the Wocklumeria sphaeroides Subzone. The Middle costatus Subzone comprised the rest of Schindewolf's section, and a further 8-10 metres below this, although no ammonoids have been described from this lower level.

Brügge (1973) clearly identified the Platyclymenia/Clymenia Stufen boundary at Alte Heerstrasse, Schleiz, recognised by the appearance of Clymenia, Kosmoclymenia and Costaclymenia. The base of the Lower costatus Subzone lay below this, in the Platyclymenia Stufe.

praesulcata and sulcata Zones: Protognathodus faunas

Devonian-Carboniferous boundary

The Devonian-Carboniferous boundary is defined provisionally as the base of the sulcata Zone (Paproth 1980). Faunas of the praesulcata Zone below this, were first recognised by Sandberg *et al*. (1972), and a formal zone was later established as the lowest of the otherwise Lower Carboniferous *Siphonodella* zonation (Sandberg 1978). It is restricted to clastic regressive marine facies, and has been recognised in Germany as low as the Middle *costatus* Zone (Klapper and Ziegler 1979). Thus it partly overlaps, and continues above the *costatus* Zone, until the appearance of the *sulcata* Zone fauna.

In 1969 Ziegler described a newly named *Protognathodus* fauna, obtained by processing matrix from *Acutimitoceras prorsum prorsum* and *Acut. carinatum* collected from Stockum by Schmidt (1924,5). He had identified from the same level one specimen of *Gattendorfia* and so this fauna was assigned to the Lower Carboniferous. However, Ziegler (1969) and Koch *et al*. (1970) found none of the conodonts typical of the lowermost Carboniferous *dentilineata-kockeli* Zone (later renamed the *sulcata* Zone) and so considered the Stockum Limestone horizon as uppermost Devonian in age.

The questions that this apparent contradiction provoked were partly answered by recollecting from the Stockum Limestone freshly exposed by trenching (H. Alberti *et al*. 1974). The goniatite fauna of the 7cm thick Stockum Limestone was shown to comprise *Imitoceras* only, and Schmidt's report of a *Gattendorfia crassa* had been considered (Weyer 1965) to be an incorrect identification of a juvenile *Imitoceras* with an open umbilicus (but can now be recognised as an *Acutimitoceras*). Unfortunately no details of the precise nature of the goniatite fauna were published by Alberti *et al*. but by reference to Schmidt (1924,5) Weyer (1965, 1977) and Vöhringer (1960) they can be interpreted as follows:

Schmidt 1924	Weyer 1977
Ag. infracarbonicum	*I. intermedium*
Ag. intermedius	*I. subbilobatum*

Aq. sciotoensis	Acut. carinatum
Gatt. crassa	Acut. prorsum

Alberti et al. (1974) observed that although no Gattendorfia were encountered at Stockum some of the Imitoceras had an open umbilicus and a lateral lobe centred outside the umbilical seam. They took this as the earliest available evidence of Gattendorfia-like characteristics in goniatites, which they said had appeared after the extinction of the clymeniids. Therefore, they proposed that the Stockum Limestone be included within the Carboniferous.

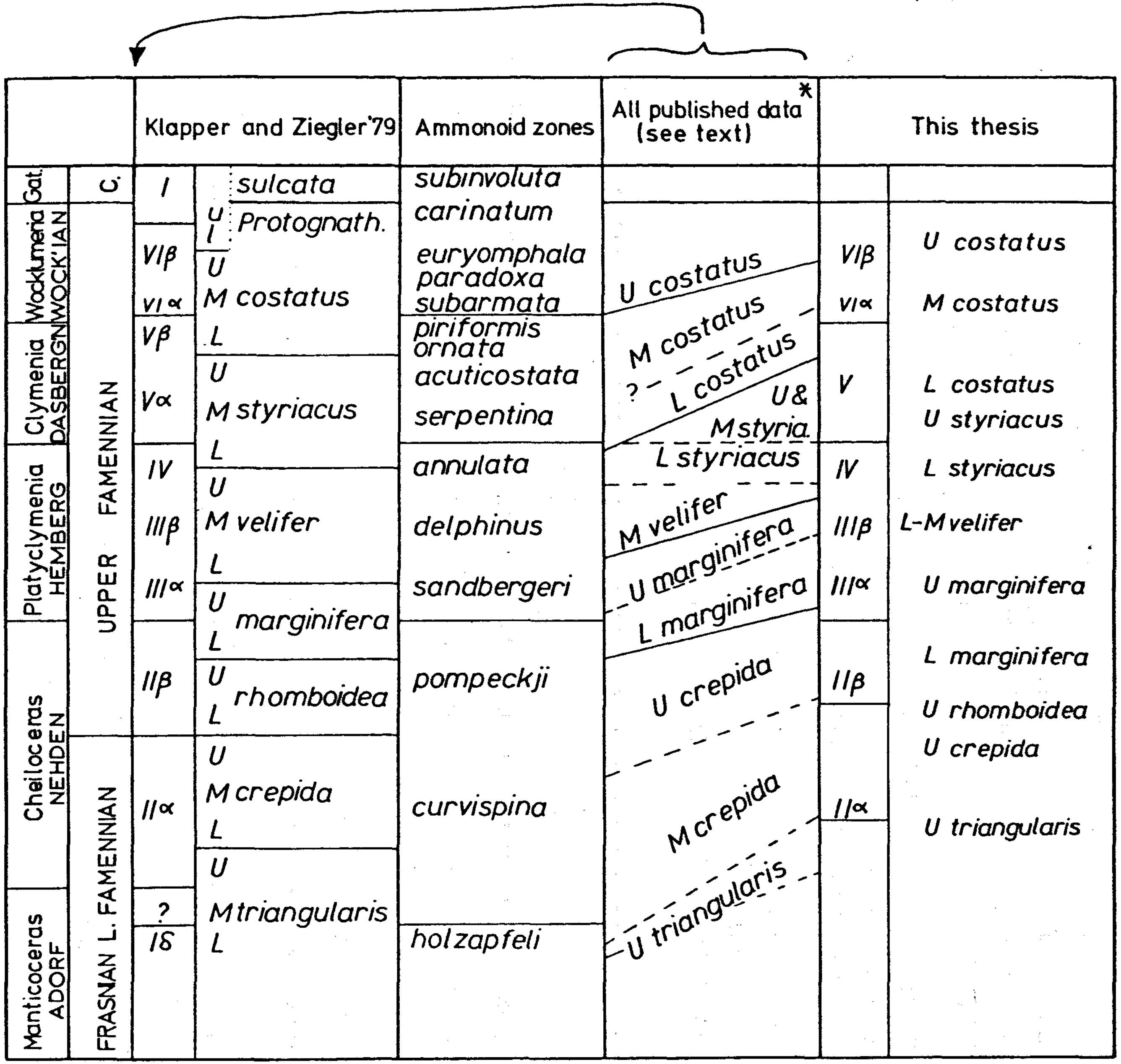
Alberti et al. also investigated the conodont faunas at Stockum. The Protognathodus fauna was divided into an upper and lower part, with and without Prot. kuehni. They admitted the Pr. kuehni was a very rare element of the fauna. It was first encountered in the Stockum Limestone, and, following Collinson et al. 1971, and Sandberg et al. 1972, this was placed in the Lower Carboniferous, with only the lower Protognathodus fauna in the Upper Devonian.

No further relevant information on these horizons has been published, although Korn (1981b) has described species of Imitoceras and Acutimitoceras from a sequence nearby at Müssenberg, developed wholly in limestones, across the Devonian-Carboniferous boundary.

Summary

A summary of the information outlined here can be found in Textfig. 6.3. It can be seen that there are some quite major discrepancies in correlation with the ammonoid zones, between the scheme adopted by Klapper and Ziegler (1979) and a synthesis of all the available information. New data, presented below, largely confirms the scheme adopted by Klapper and Ziegler (1979), in spite of the fact that they did not then, nor earlier, justify their reasons for ignoring some of the correlations they had themselves

Textfig. 6.3



Correlation between ammonoid and conodont zones.

* This column would be better understood if moved as indicated.
The inclined lines indicate the uncertainty with which the
conodont and ammonoid zones can be correlated, using published
information. Thus the base of the L. costatus Zone is reported at
positions between Zone IV, and the Vα/Vβ boundary.

presented (e.g. Ziegler 1962, 1971b). The only important error revealed by research for this thesis is in the position of the curvispina/pompeckji Zone boundary in terms of the conodont zonation, and data for the correct position of this was already available in the literature (Altestal, Sandberg and Ziegler 1973, Fuhrmann 1954; Kasig et al. 1979, Schindewolf 1921).

New data relating to the ammonoid/conodont zonal correlation

Approximately 30 conodont samples have been prepared from horizons or ammonoid specimens, either to date accurately type-specimens for museum collections, or to help clarify correlation between the ammonoid and conodont zonations. The results are set out below and summarised in Textfig. 6.3. The initials in brackets indicate which conodont workers kindly dated the samples: WZ = Prof. W. Ziegler, RD = Dr. R. Dreesen, IS = Dr. I. Stewart.

1) Cryptoclymenia beaumonti holotype, BSP AS VII 534
   Gattendorf
   Middle - Upper costatus Zone (WZ)

2) Kosmoclymenia undulata, HU P82.11
   Reigern, Bed 33, subarmata Zone
   Middle costatus Zone (IS)

3) Kosmoclymenia undulata (proposed neotype) SMF
   Reigern, Bed 23, subarmata Zone
   Lower costatus Zone (IS)
   N.B. The section at Reigern was dated by Schäfer (1978, Proben 184a/2,1, 184/1-10, abb. 10E) as entirely within the Middle costatus Zone.

4) Kosmoclymenia subundulata SM H10388
   Schübelhammer
   Lower costatus Zone (WZ)

5) Kosmoclymenia inaequistriata (proposed neotype) SM H10376
   Schübelhammer
   Upper styriacus - Lower costatus Zone (WZ)

6) *Cymaclymenia* sp. *a* (= *warsteinensis* Korn *partim*) HU P82.5
Effenberg
? Upper *styriacus* - ? Lower *costatus* Zone (IS)

7) *Kosmoclymenia subundulata* SM H10389
Schübelhammer
Upper *styriacus* Zone (WZ)

8) Gen. Nov. *F costata* BSP AS VII 529
Geuser
Lower *costatus* Zone (WZ)

9) *Platyclymenia richteri* HU P82.3
Middle - Upper *styriacus* Zone (RD)

10) Sample 1980/352, HU P82.14
Beil
Lower - Middle *styriacus* Zone (RD)

11) HU P82.40
Nodule band, Kattensiepen, *annulata* Zone
younger than Middle *styriacus* Zone (WZ)

12) HU P82.41
Beil, Beds A 1-10
Lower *styriacus* Zone (RD)

13) ? Gen. Nov. *F decorata*, BSP AS VII 533
Geuser
not younger than Middle *velifer* Zone (WZ)

14) *Cycloclymenia clymenioides* (holotype), UEN
? Gattendorf
Upper *marginifera* Zone (WZ)

15) *Cycloclymenia planorbiformis sensu* Gümbel, SM H10375
Gattendorf
Upper *marginifera* Zone (WZ)

16) 1980/378
Geuser, includes *Ps. sedgwicki*
Upper *marginifera* Zone (IS)

17) *Pseudoclymenia dillensis*, DK 28
Beil, IIα
marginifera Zone (IS)

18) Bed 9f
Beil, IIβ
Lower *marginifera* Zone (RD)

19) Bed 11g
Beil IIβ, lowest level with Sporadoceras
lowermost marginifera Zone (RD)

20) Bed 15a
Beil IIα, lowest level with Dimeroceras
Upper rhomboidea Zone (RD)

21) Nodules with Gen. nov. sp. nov. (= Falcitornoceras falciculum falciculum, House and Price, in preparation)
Nehden, IIα
a) Upper crepida Zone (WZ)
b) rhomboidea Zone (RD)

The important points from these results are summarised below, with the relevant samples referred to by numbers in the left-hand margin. The base of the pompeckji Zone, recognised at Beil (see Chapter 7) by the appearance in Bed 11g of Sporadoceras (Sp.) biferum lies in the lowermost marginifera Zone (19). Previously the curvispina/pompeckji Zone boundary has been correlated with that between the crepida and rhomboidea Zones. Dimeroceras appears below in Bed 15a, curvispina Zone, falling in the Upper rhomboidea Zone (20).

Pseudoclymenia, which appears in the sandbergeri Zone, was collected from a level yielding a marginifera Zone fauna at Beil (17). A level below this, Bed 9f, yielded a pompeckji Zone ammonoid fauna together with Lower marginifera Zone conodonts (18). A sample from Geuser, Oberfranken, which contained Pseudoclymenia sedgwicki yielded an Upper marginifera Zone fauna (19). Matrix from two species of Cycloclymenia (14,15) yielded an Upper marginifera Zone fauna, also. Previously this genus has been thought to occur in the Clymenia Stufe.

Unfortunately no velifer Zone faunas collected in situ have been isolated. However, Ziegler (1971a) did report a Middle velifer Zone fauna from the delphinus Zone at Hövel, recognised by the presence of Cyrt. involuta and Prol. delphinus.

Faunas indicative of the annulata Zone have yielded Lower styriacus (12), Middle styriacus (11) and Middle-Upper styriacus (9) Zone faunas. Above this level common clymeniid species appear to have relatively long ranges, and no conodont faunas have been obtained from any of the index fossils for the Clymenia and Wocklumeria Stufen. Kosmoclymenia subundulata has been recorded from rocks yielding a Lower-Middle styriacus (10) and a Lower costatus (4) Zone fauna. Matrix from the neotype of Kosmo. inaequistriata yielded an Upper styriacus - Lower costatus Zone fauna (5). Kosmoclymenia undulata has been collected from levels yielding a Lower (3) and Middle (2) costatus Zone fauna. None of these three species is restricted to one particular ammonoid zone, although fauna 2 was obtained from a level within the subarmata Zone.

Occurrence of these species of Kosmoclymenia allows the upper part of the lower Clymenia Stufe to be correlated with the Middle styriacus Zone, the upper Clymenia Stufe to be correlated with the Upper styriacus Zone and the subarmata Zone to be correlated with the Middle costatus Zone.

Appendix 1

Faunal lists used to date conodont samples detailed above. Workers who identified the species were indicated by their initials above.

Sample		Specimen	Conodont fauna
1		BSP AS VII 534	Bispathodus ultimus and related forms
2	1,2	HU P82.11	Palmatolepis gracilis gonioclymeniae
	3		Pa. g. gracilis
	6,7		Pa. g. sigmoidalis
	20,34,37		Spathognathodus inornatus
	17,18		Bi. costatus
	19.?24		Pseudopolygnathus cf. dentilineatus
	23		Bi. aculeatus aculeatus
	26		Bi. stabilis
3		SMF	Bi. aculeatus aculeatus
4		SM H10388	Bi. aculeatus
			Bi. costatus
			Pa. gracilis gracilis
			early Bi. jugosus
5		SM H10376	Bi. stabilis
			"Spathognathodus" fissilis
			"Sp." werneri
			Pa. gracilis gracilis
6		HU P82.5	Polygnathus communis communis
			Bi. stabilis
7		SM H10389	Pa. styriacus (late form)
			Bi. stabilis morphotypes 2 and 3
8		BSP AS VII 529	Pa. gracilis gracilis
			Pa. g. sigmoidalis
			Pa. schindewolfi
9		HU P82.3	Pa. gracilis gracilis
			Pa. g. sigmoidalis

		Pa. minuta minuta
		Po. granulosus
10	1980/352	Pa. g. sigmoidalis
		Pa. perlobata schindewolfi
		Pa. styriaca
		Pa. subirregularis
11	HU P82.40	Scaphignathus subserratus
12	HU P82.41	Pa. g. sigmoidalis
		Pa. perlobata schindewolfi
		Bi. stabilis
		Po. styriacus
13	BSP AS VII 533	Pa. glabra distorta
		Pa. schindewolfi
14	HU P82.42	Pa. glabra pectinata
		Pa. maxima
		Pa. gracilis gracilis
		Pa. minuta
		Pa. schleizia
		Icriodus alternatus
15	SM H10375	Pa. schindewolfi
		Pa. glabra pectinata
		Pa. glabra acuta
		Pa. helmsi
		Pa. cf. grossi
		Pa. glabra distorta ?
16	HU P82.43	Pa. marginifera marginifera
		Pa. perlobata schindewolfi
		Pa. glabra distorta
		Pa. gracilis gracilis
		Pa. perlobata grossi
		Pa. minuta schleizia
		Po. glaber bilobatus
17	HU P82.44	No details
18	HU P82.45	Pa. marginifera marginifera
		Pa. glabra pectinata
		Pa. inflexa inflexoidea
		Pa. perlobata schindewolfi

			Pa. glabra acuta
			Pa. gl. lepta
			Pa. gracilis gracilis
			Pa. minuta minuta
			Po. cf. rhomboideus
19		HU P82.46	Pa. minuta minuta
			Pa. inflexa inflexoidea
			Pa. stoppeli vel marginifera
			Pa. glabra pectinata
			Pa. perlobata schindewolfi
			Po. glaber glaber
20		HU P82.47	Pa. subperlobata
			Pa. tenuipunctata
			Pa. rhomboidea
			Pa. glabra prima
			Pa. gracilis gracilis
			Po. communis communis
			Po. cf. bouckaerti
			Po. glaber glaber
21a	WZ	HU P82.48	Pa. glabra pectinata
			Pa. gl. acuta
			Pa. gl. elongata
b	RD	HU P82.49	Pa. rhomboidea
			Pa. minuta minuta
			Pa. glabra pectinata
			Pa. tenuipunctata
			Pa. subperlobata

Chapter 7

Collecting localities and details of faunas

Introduction

This chapter includes details of all localities mentioned in this thesis, and specimens collected for the study. The map-sheet on which each locality occurs is listed in the first part. The second part details each of the sections from which specimens were collected and includes locality maps, measured sections, photographs and some analysis of the age and significant elements of each sample. Appendix 1 lists specimens deposited in the collections of the University of Hull. Samples are listed in Appendix 2.

Localities mentioned in the text

Localities mentioned in German literature and palaeontological collections in museums are generally referred to and organised using the names and numbers of the 1:25 000 topographic maps, e.g. Beil, Mtb (= Messtischblatt) 4613 Balve. This practice is adopted here.

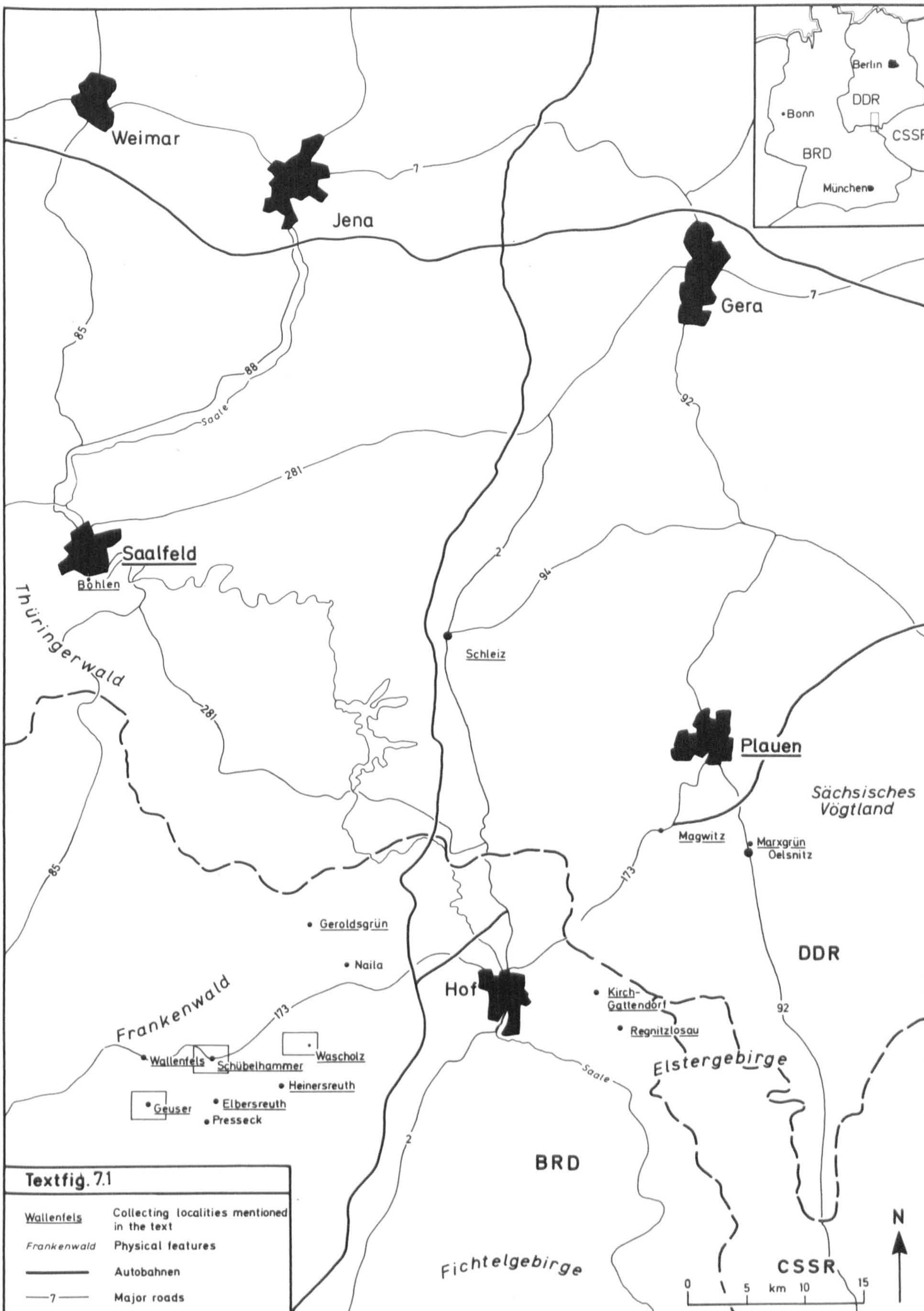
Kutscher and Schmidt (1958) published four useful maps showing German Devonian fossil localities, 1:25 000 map-sheet names, and Devonian geology. A combined geological map and key is shown in Textfig. 1.6, provided to help the reader locate localities in the Sauerland mentioned in the text, and Textfig. 7.1 shows localities in Thuringia, Sächsische Vogtland and Oberfranken.

The following localities are referred to in this thesis:

	Map Sheet		Co-ordinates	
Ainkhausen	4613	Balve	e262	n963
Altestal		Zellerfeld	e380	n460
Ballberg (see Hövel)				
Beil	4613	Balve	e210	n959
Bensberg	5008	Mülheim am Rhein	e803	n491

Beringhausen	4518	Madfeld		
Borke-Wehr	4613	Balve	e221	n887
Bilsteinhöhle	4515	Hirschberg	e532	n984
Burg	4613	Balve	e227	n895
Cromford	4607	Heiligenhaus	e600	n862
Dachskühle	4708	Elberfeld	e717	n845
Dahlsen	4513	Neheim-Hüsten	e275	n965
Dasberg	4613	Balve	e242	n935
Deinstrop	4613	Balve	e238	n957
Drewer	4516	Warstein	e555	n067
Effenberg	4613	Balve	e278	n959
Elbersreuth	5735	Schwarzenbach am Wald	e685	n681
Ense	4820	Bad Wildungen		
Geuser	5734	Wallenfels	e616	n666
Hauern				
Heinersreuth	5735	Schwarzenbach am Wald	e708	n678
Hövel	4613	Balve	e246	n922
Kasberg	4613	Balve	e225	n867
Kattensiepen	4516	Warstein	e579	n037
Kirch-Gattendorf	5638	Bobenneukirchen	e766	n005
Kirschofen	5515	Weilburg		
Melschede (see Hövel)				
Müssenberg	4613	Balve	e293	n957
Nehden	4517	Alme		
Oberrödinghausen	4613	Balve	e194	n961
Ose	4512	Menden	e157	n969
Reigern	4613	Balve	e298	n953
Schübelhammer	5735	Schwarzenbach am Wald	e678	n693
Sessacker	5216	Oberscheld		
Stockum	4713	Plettenberg	e302	n846
Üllendahl	4708	Elberfeld		
Velbert	4608	Velbert	e80	n83
Wäschholz	5735	Schwarzenbach am Wald	e755	n695
Wocklum (see Borke-Wehr)				
Wettmarsen	4613	Balve	e247	n943

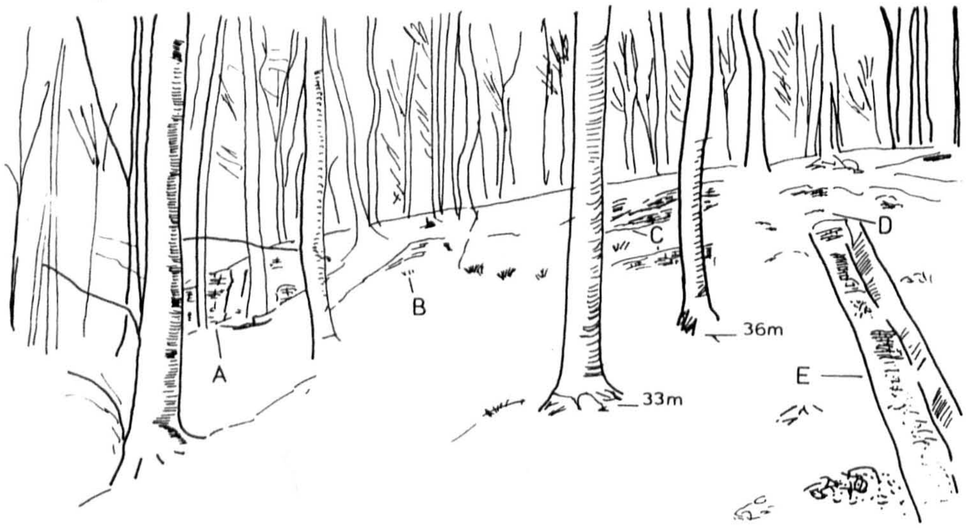
Localities from which collections were made are described individually, below.



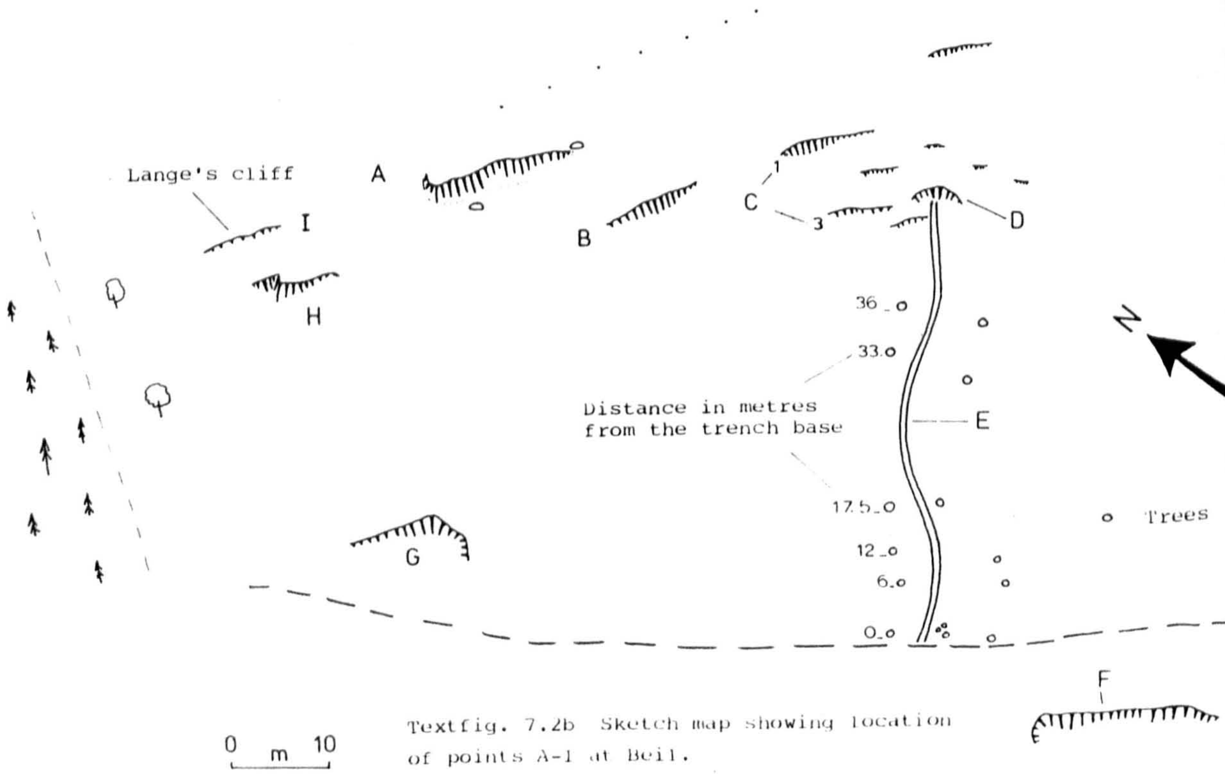
Map showing localities in Thuringia, Oberfranken and Sachsische Vogtland which are mentioned in the text. Detailed maps of the areas in small boxes are provided in Textfig. 7.15

Plate 7.1

Beil. Illustrations showing (a) location of outcrops A-D, and upper part of Trench E, and (b) the full extent of the trench. A map of the trench, and associated outcrops is provided in Textfig. 7.10. Detailed sections are shown on Textfig. 7.9. Textfig. 7.2a indicates precisely where the sections are to be found on the illustrations, and Textfig. 7.2b is a detailed map of the area covered by the illustrations.



Textfig. 7.2a



Textfig. 7.2b Sketch map showing location of points A-I at Beil.

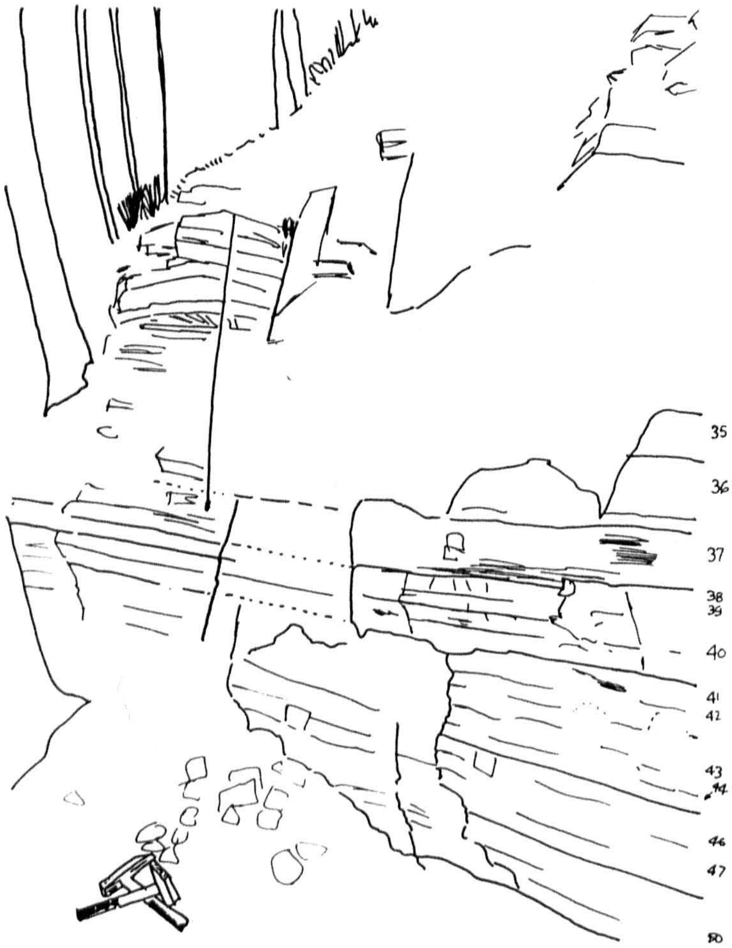
PLATE 7.1

a

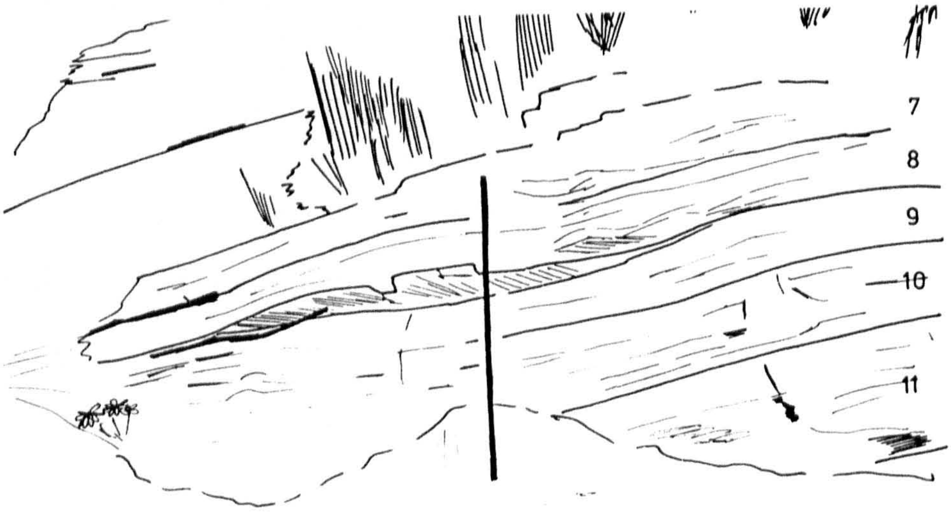
b

a Outcrop at Beil, location A. Beds numbered in the detailed section (Textfig. 7.9) are indicated in the sketch opposite, Textfig. 7.3a. The scale is 1m in length.

b Outcrops at Beil, location C1. Beds are numbered below in Textfig. 7.3b. The scale is 50cms in length.



Textfig. 7.3a Beil, outcrop A



Textfig. 7.3b Beil, outcrop C1

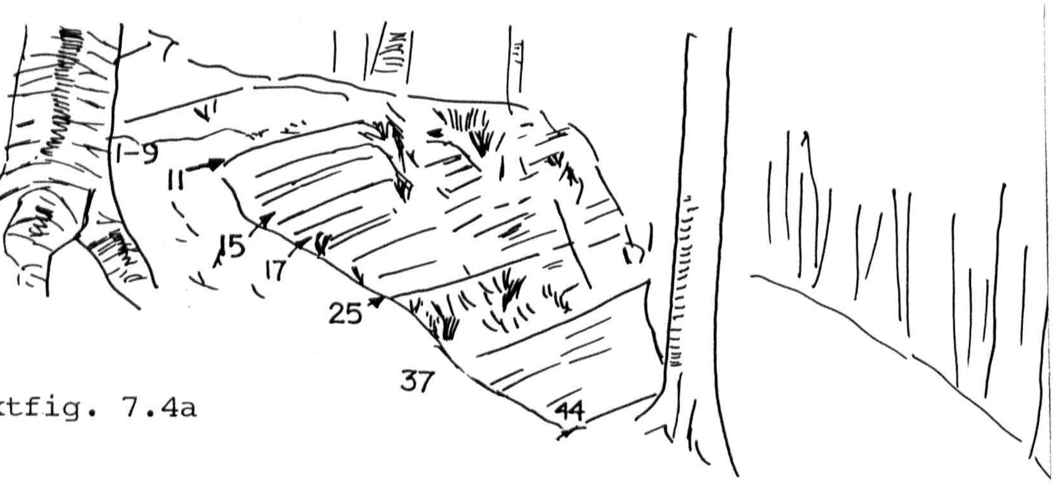
Plate 7.2


a


b

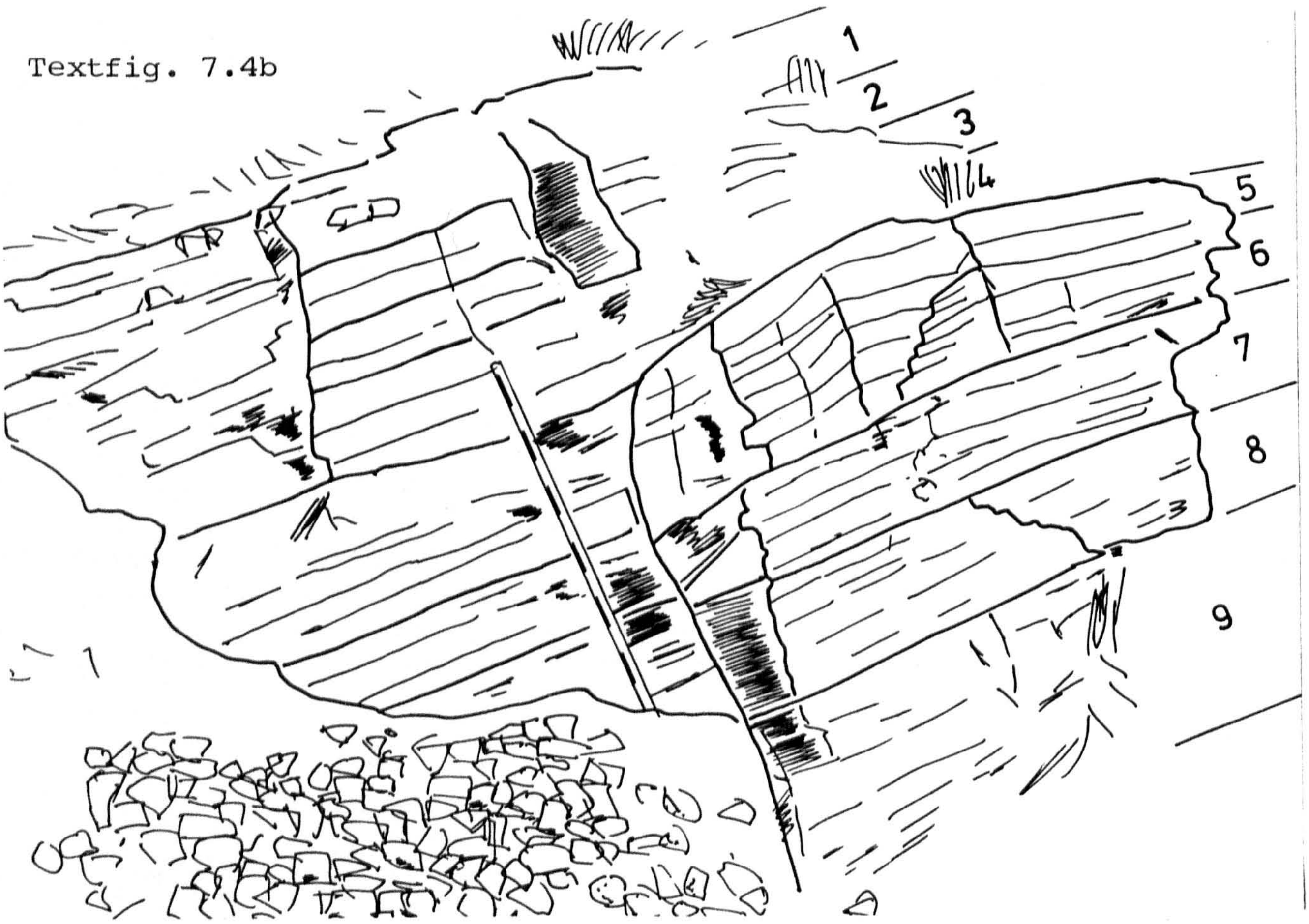
Plate 7.3

a Beil location A, with Bed numbers indicated on the sketch below, (Textfig. 7.4a.



Textfig. 7.4a

Textfig. 7.4b



b Beil, location H. This is the outcrop referred to by Ziegler (1962) as "untere Klippe". Bed numbers are shown above on Textfig. 7.4b. The scale is 1.25m long.

PLATE 7.3

a

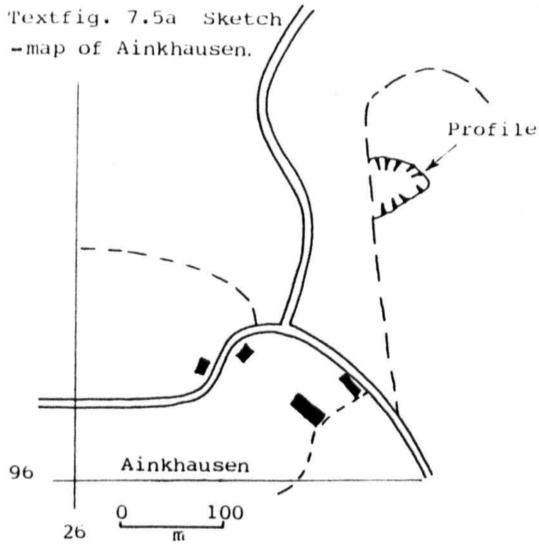
b

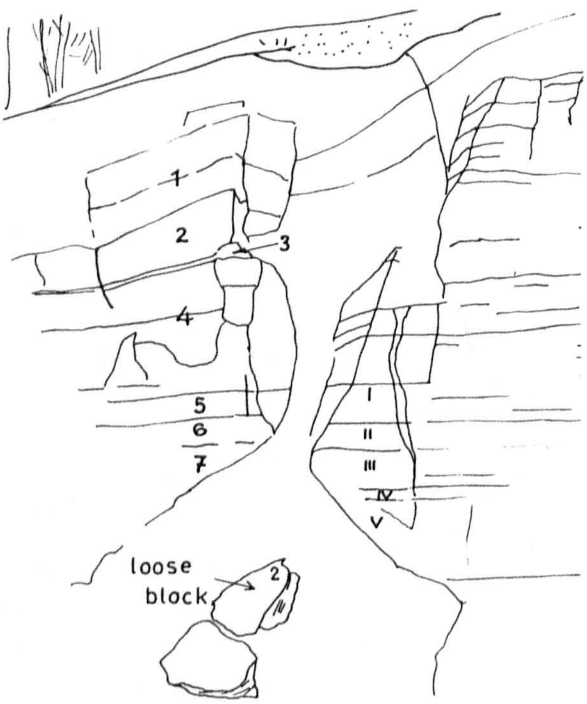
Plate 7.4

a Ainkhausen quarry (4613 Balve: e262 n963). The inset shows the quarry face profile. The scale is 1.25m in length. The two blocks in the foreground were the principal sources of material.

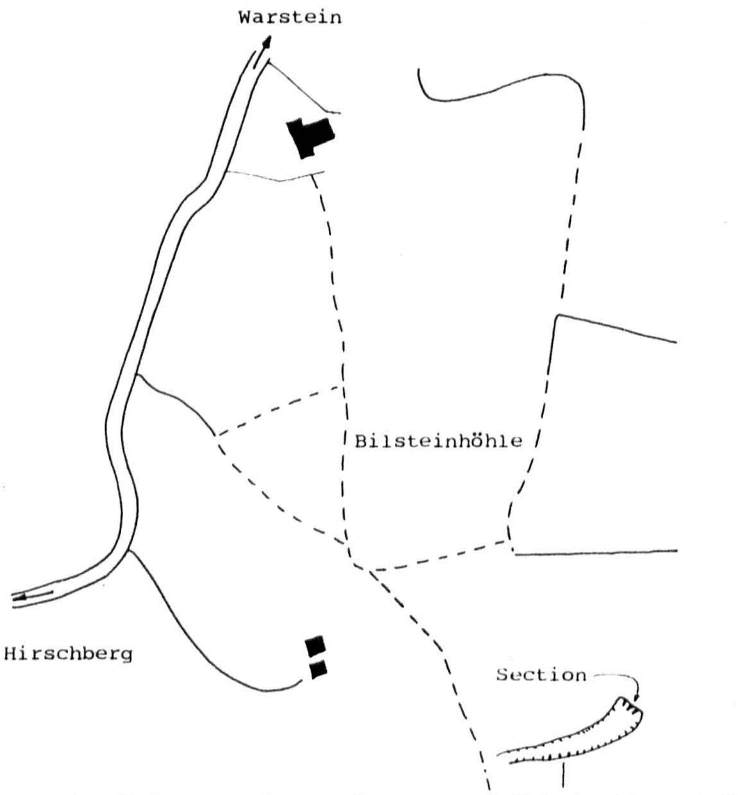
b Bilsteinhöhle, old shooting range (4515 Hirschberg: e532, n 989). A profile of this section was given by Clausen *et al.* (1979, fig. 4). Numbers in square boxes on the sketch (Textfig. 7.5d) were visible painted on the rock face in 1980. Three-figure numbers are sample numbers. Clausen *et al.* demonstrated that the bedding planes were not regular, being affected by slumping.

Textfig. 7.5a Sketch-map of Ainkhausen.





Textfig. 7.5b Section at Ainkhausen



Textfig. 7.5c Sketch map of Bilsteinhöhle

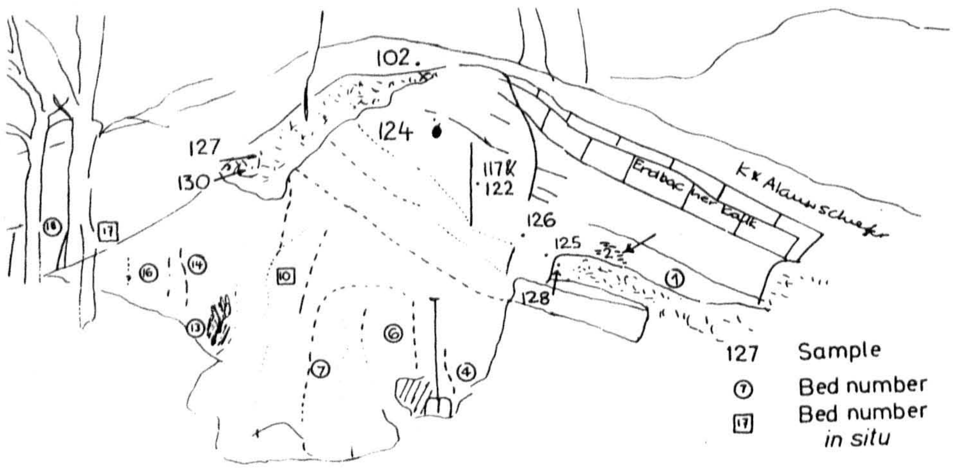
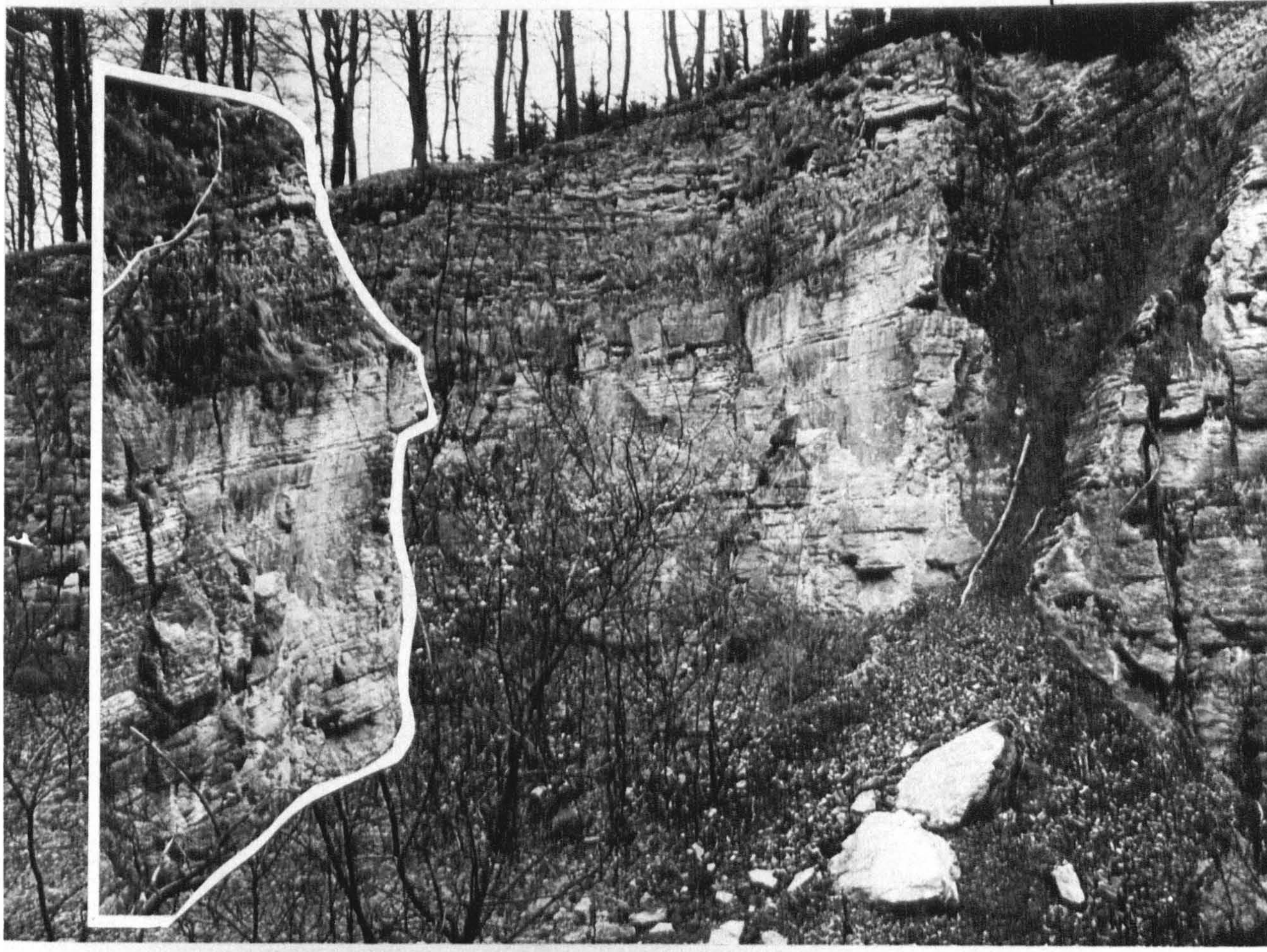


PLATE 7.4



a

b

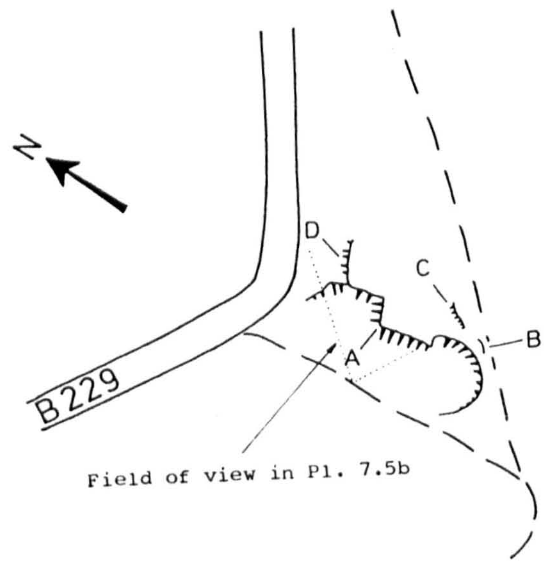
Plate 7.5

Hövel, old quarry on the B229, 1.5km south south west of Hövel (4613 Balve e246 n922).

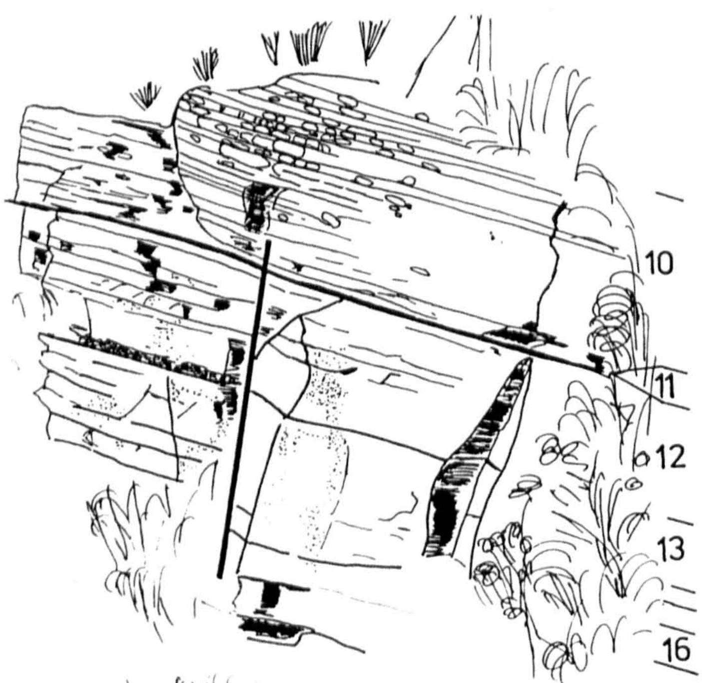
a Section C, which is detailed in Textfig. 7.6a. The scale is 1.25m in length. Details of beds are given in Textfig. 7.16a.

b View of the main quarry, showing the prominent change in lithology coincident with the Annulata Shale. The scale is 2.5m in length. Bed numbers are after Ziegler 1971a, and details are given in Textfig. 7.16b.

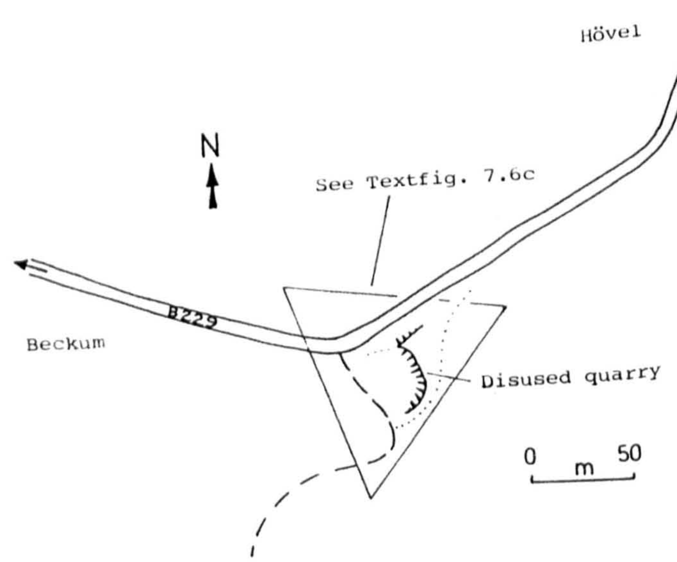
Textfig. 7.6a Hövel, section C



Textfig. 7.6c Sections at Hövel.



Textfig. 7.6d Hövel, section A



Textfig. 7.6b Sketch map of old quarry near Hövel

PLATE 7.5

a

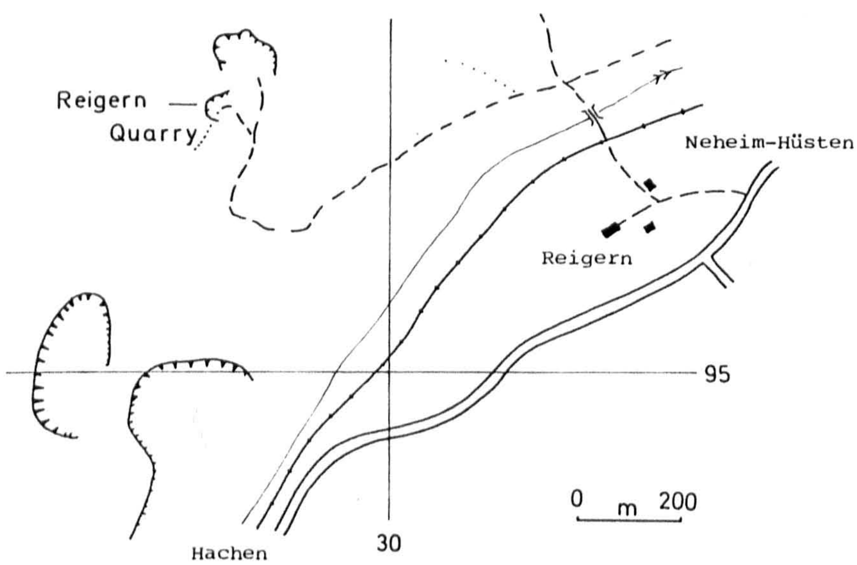
b

Plate 7.6

a Drewer (4516 Warstein: e555 n067). Slumping in upper Famennian limestones at the Ost Provinzial Steinbruch, north face. The scale is 4m in length.

b Reigern Quarry (4613 Balve: e298 n393). Bed numbers are shown on the sketch below (Textfig. 7.7b). A detailed section is given in Textfig. 7.20. The scale is 1.25m in length.

Textfig. 7.7a Sketch map of Reigern



Textfig. 7.7b Measured profile at Reigern.

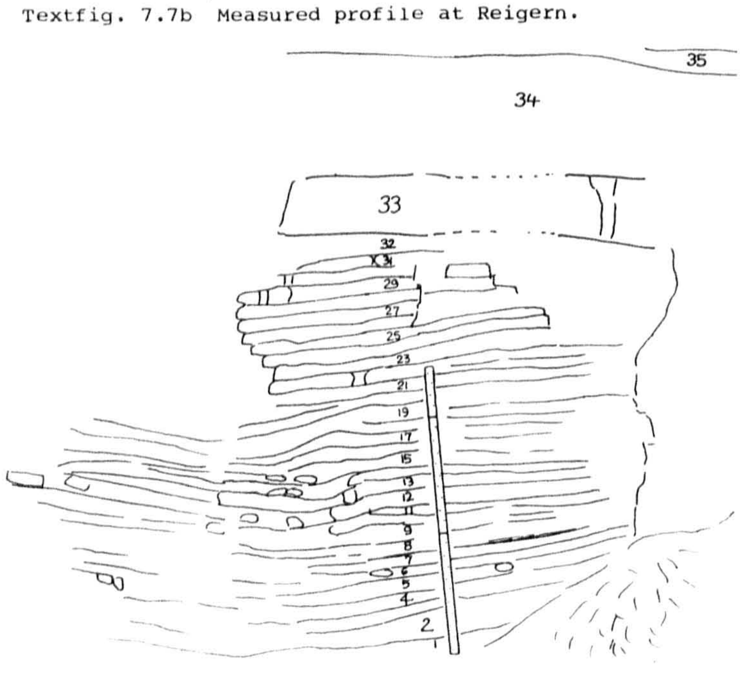
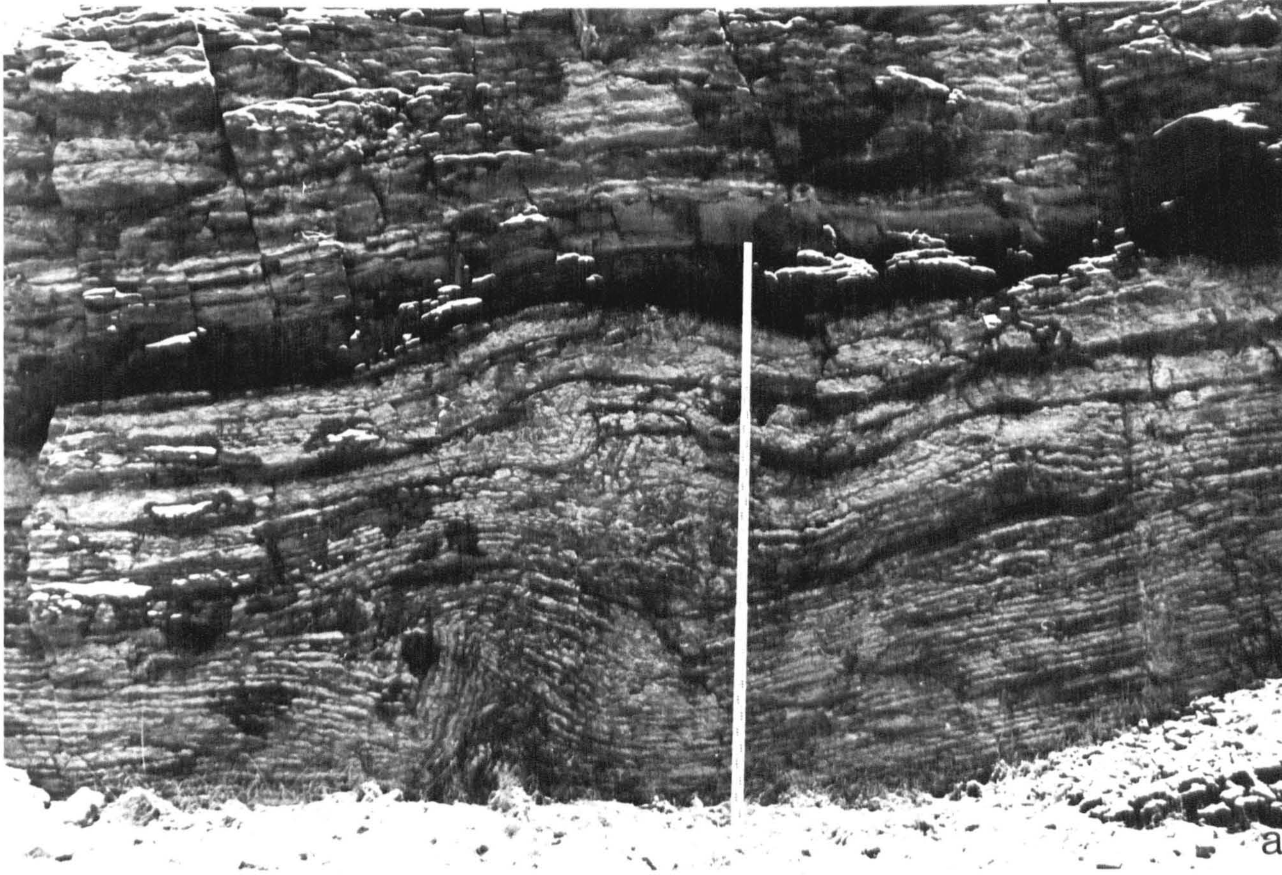
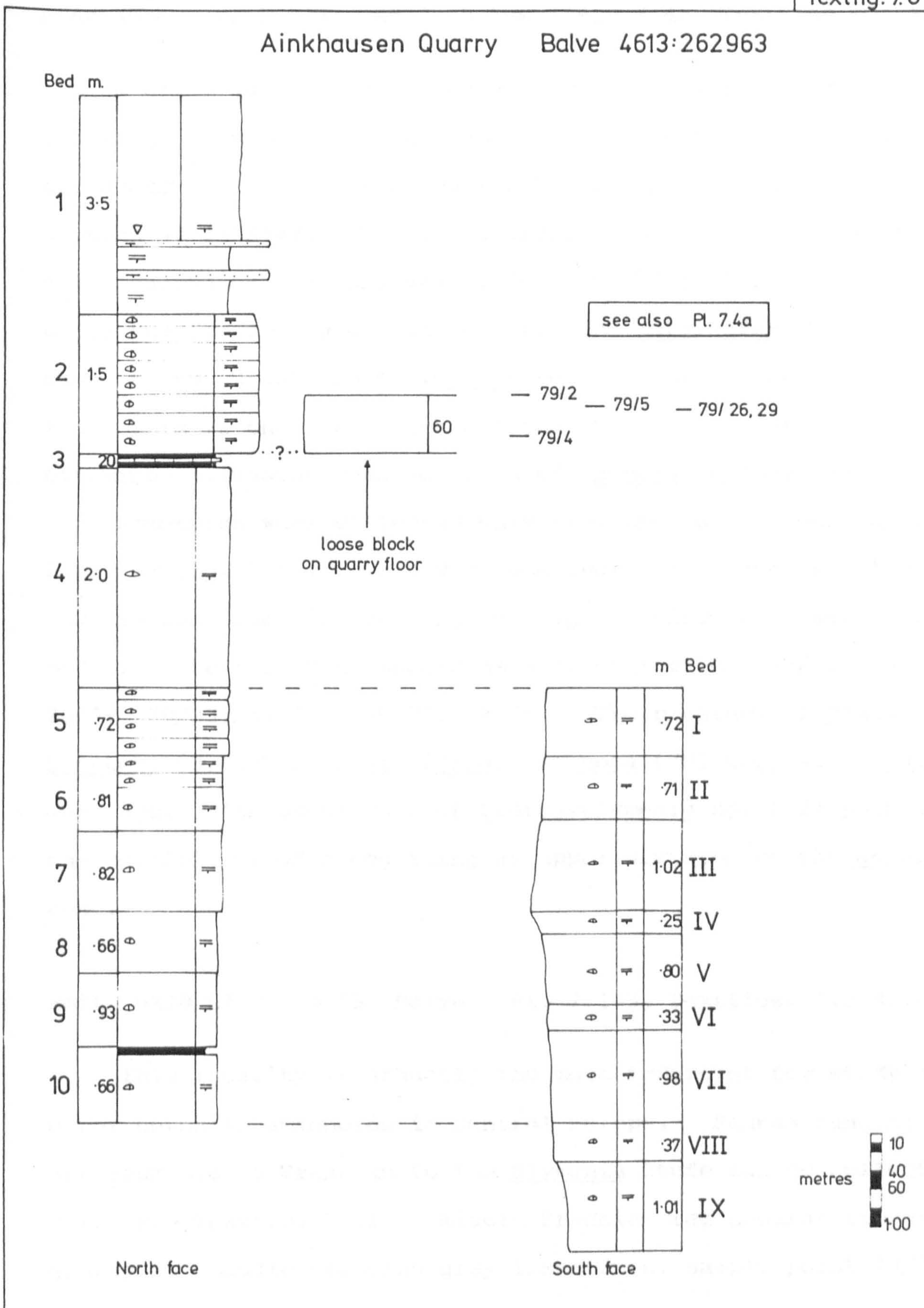


PLATE 7.6




Ainkhausen Quarry Balve 4613:262963
Bed m.
1 3·5
2 1·5
3 20
4 2·0
5 ·72
6 ·81
7 ·82
8 ·66
9 ·93
10 ·66
see also Pl. 7.4a
60
79/2
79/5
79/ 26, 29
79/4
loose block on quarry floor
m Bed
·72 I
·71 II
1·02 III
·25 IV
·80 V
·33 VI
·98 VII
·37 VIII
1·01 IX
metres
10
40
60
1·00
North face
South face

Collecting localities

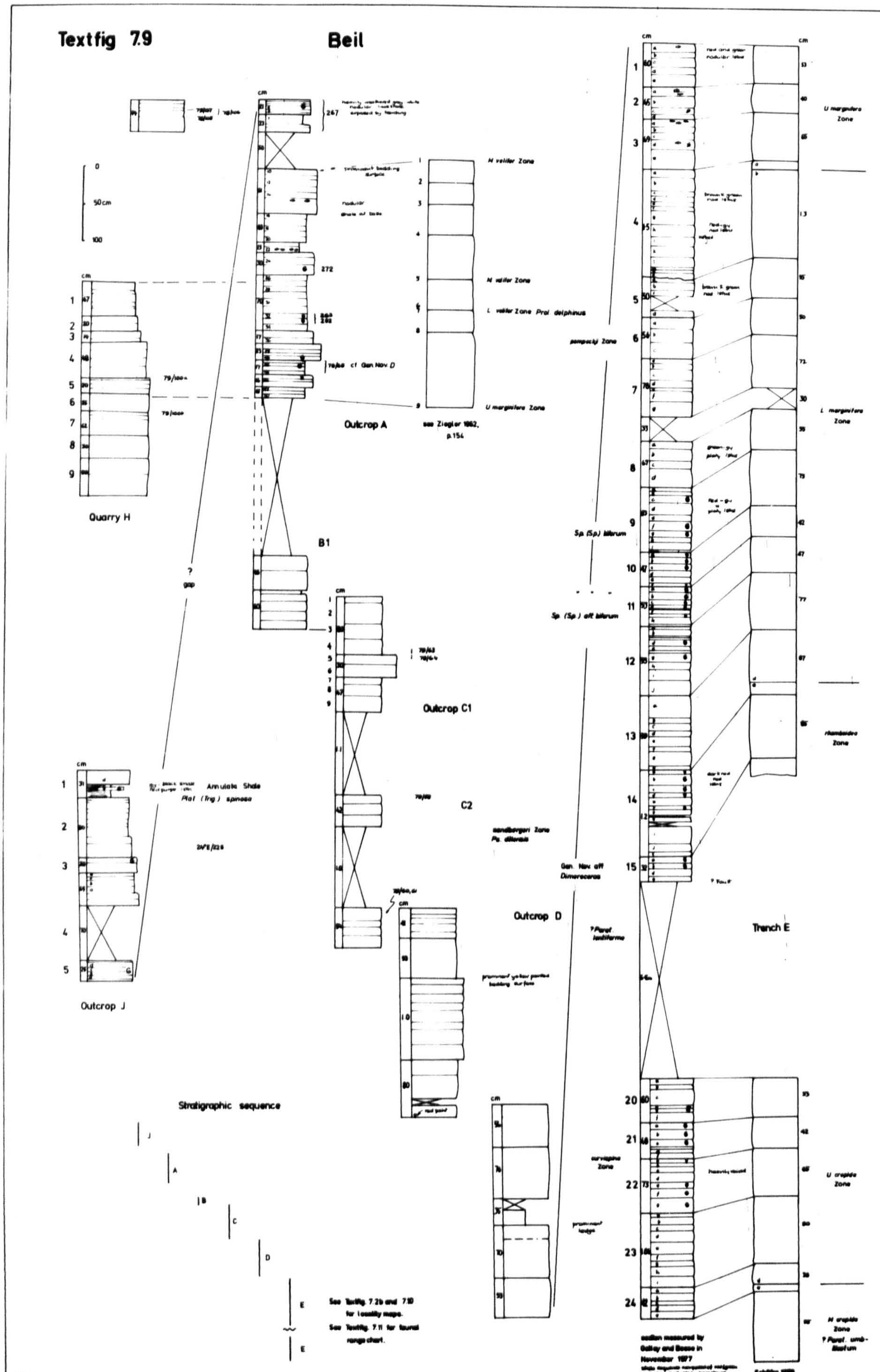
Ainkhausen e262 n963 4613 Balve Pl. 7.4a, Textfigs. 7,5a,b,7.8

A small quarry reached by a track running for 250m north from the large farm-house in the hamlet of Ainkhausen. Exposed in the quarry are 20m of red nodular Famennian limestones (Pl. 7.4a), dipping at 14E/342. The inset profile on the plate shows the notch caused by the Annulata Shale. Schäfer (1978, p. 93 Probe 6) dated the limestones as ranging from the marginifera Zone at the base, to the Middle/Upper velifer Zone at the top of the section. Above this is the Lower Carboniferous Kieselschiefer, in which a bituminous limestone was dated as of anchoralis Zone age.

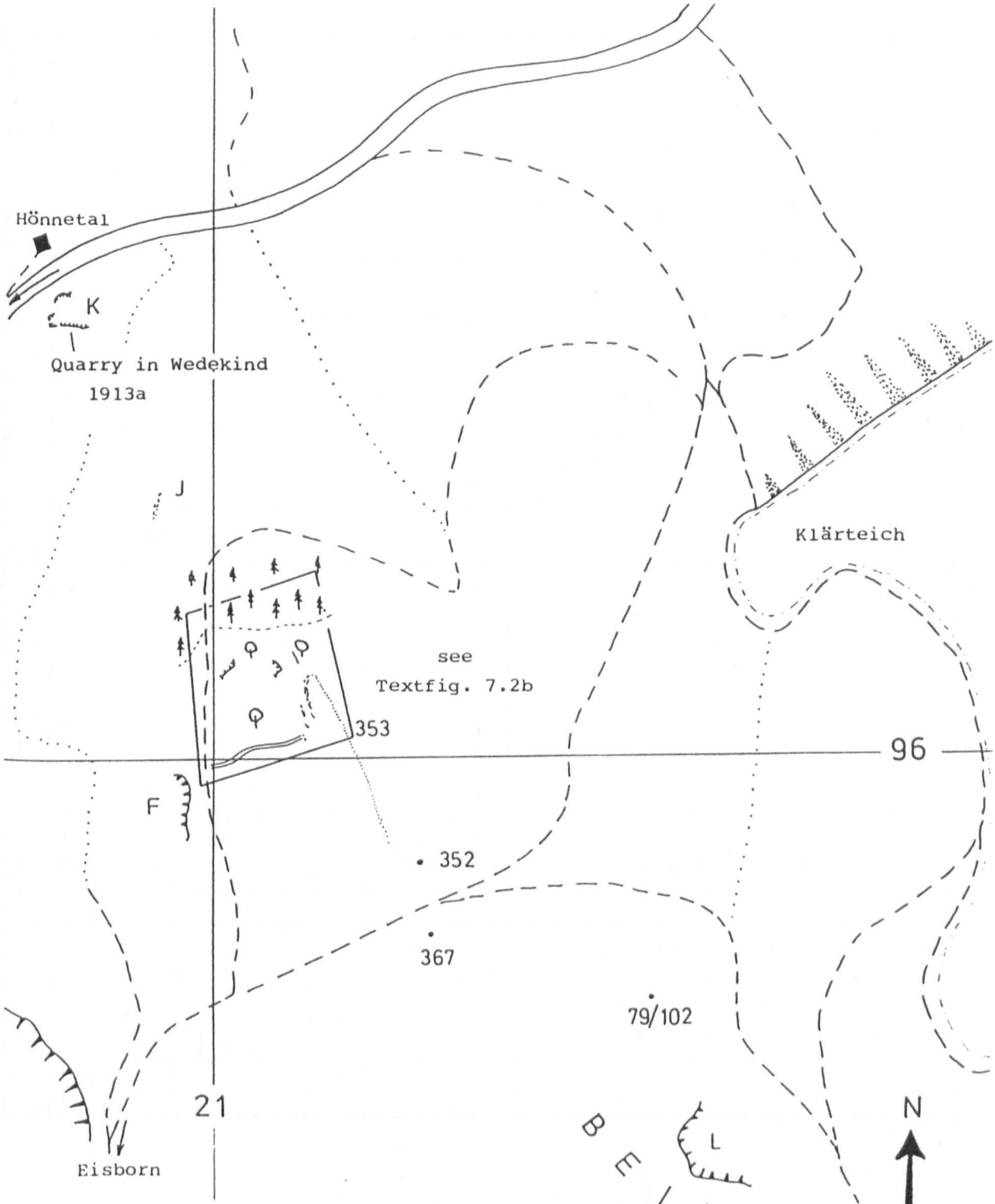
Ammonoids were collected only from the loose block labelled 2 in Textfig. 7.5b. This was some 60cm thick, and is believed to have fallen from the overhanging ledge forming the lower part of Bed 2. The following specimens were collected: 79/2, 51-60, 2081; 79/23, 61-71; 79/25, 72-76. The presence of Plat. (Plat.) richteri (3,61) and Plat. (Trig.) spinosa (70) suggest an annulata Zone age. The occurrence of Protoxyclymenia sp. (62) points to the possibility of recognising an upper division to the annulata Zone.

Beil e210 n960 4613 Balve Pl. 7.1-3, Textfigs. 7.2-4,9-11, 21

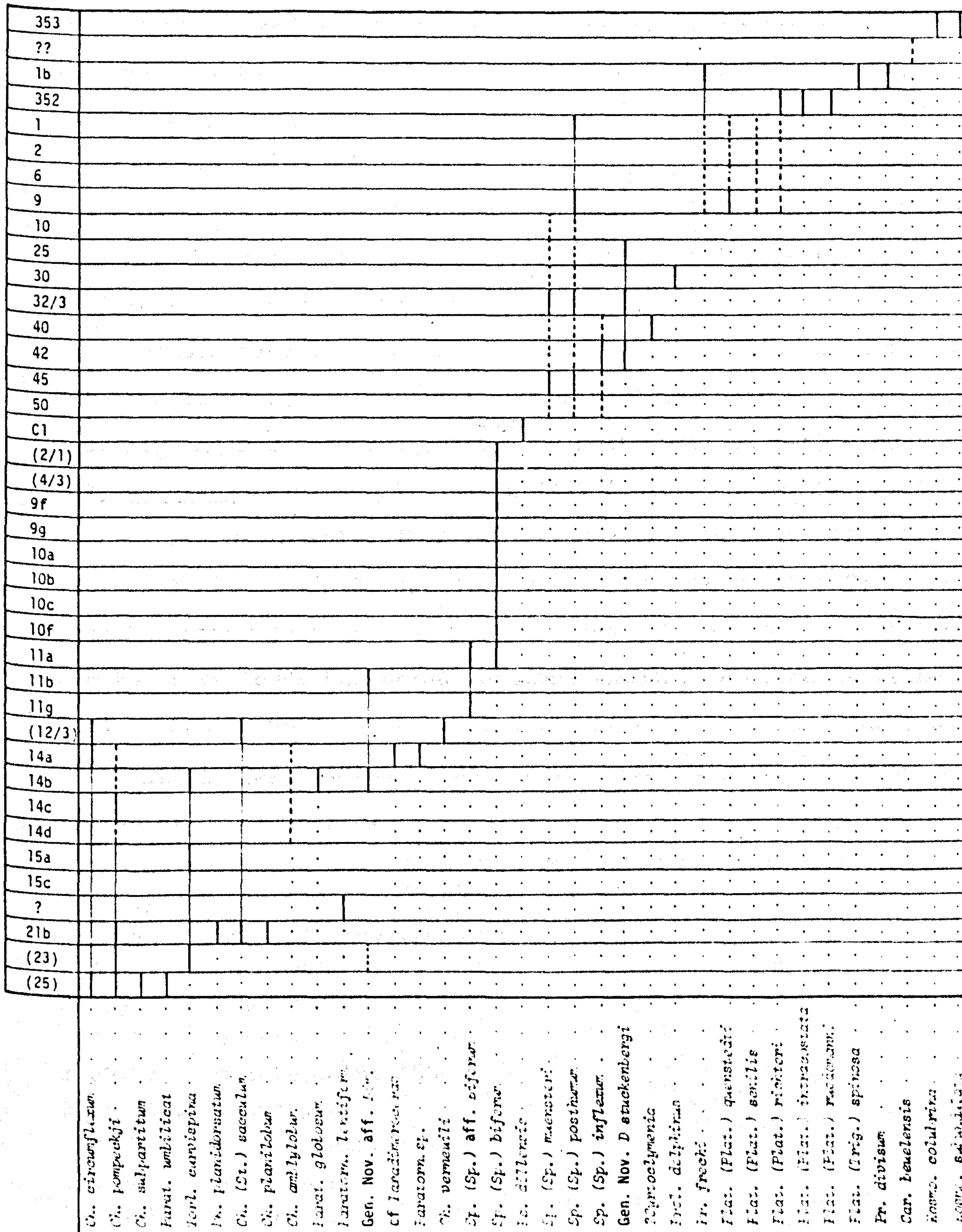
This locality is arguably the most important for study of Upper Devonian ammonoids in central Europe. Faunas ranging in age from middle Frasnian to the Clymenia Stufe can be collected here (see Textfig. 7.2b): middle Frasnian red nodular limestones, quarry K; middle Frasnian grey limestones, sample point 79/102, exposed in a shallow surface trench; Kellwasser Limestones and nodular limestones in which lie the Frasnian/Famennian boundary,



Also see enclosure



Textfig. 7.10 Sketch map of Beil
showing localities



Textfig. 7.11 Faunal range chart, Beil (seeTextfig. 7.9 for samples).

quarry K (see Wedekind 1913b); the same faunal levels must be exposed in quarry F, but no identifiable fauna could be collected from here; limestones of crepida to marginifera Zone age are exposed in outcrop D, Trench E, sample point 367, and probably in quarry G; velifer Zone limestones are present in quarry H and in outcrops A,B and possibly C and D; styriacus Zone limestones are present at the top of outcrop A, and fossiliferous levels have been now largely removed from outcrops I,J and from a trench (sample 353) marked by the dotted line.

Authors have reported faunas from these localities in the past: Wedekind 1913b (quarries K,L); Wedekind 1914 (unknown locality, possibly the now obscured quarry 10m north east of sample point 367, annulata Zone fauna); Lange 1929 (outcrop I is the remains of his trench); Ziegler 1962 (quarry H is his "untere Klippe", and outcrop A his "obere Klippe"); Schäfer 1978 (his Probe 250 came from the upper part of quarry F and Trench E was commissioned for him to study lower Famennian conodont faunas, reported as Probe 210). Schindewolf and Paeckelmann collected a large fauna from the Gonioclymenia Stufe, which now lies unstudied in the Museum für Naturkunde, Berlin.

The following specimens were collected for this study:

2211-4360	in situ from Trench E
2244	outcrop C
2245-6	quarry H
2247-87	outcrop A
2288-97	sample point 353
2298-2301	outcrop A
2302	sample point 367
2303-6	outcrop A
2307-11	outcrop J
2312-13	sample point 352
2314-5	sample point 352
	collected from the debris from Trench E

Specimens collected in situ from Trench E were obtained by Sarah Gatley and Tony Beese in November 1977, when the trench was still continuously exposed. A number of specimens (2316 et seq.) were collected from the trench spoil in 1979/80, but their original horizon cannot be accurately determined. They are not listed here. When the trench was being excavated students from the University of Marburg collected 150 specimens from the debris, noting their position in metres from the base of the trench. This distance was correlated with particular beds by means of the diagram in Textfig. 7.21. Identifiable specimens are listed below. Two points of interest arose from these specimens. Complex cheiloceratids (Parat. umbilicatum) enter in Bed 25 (Bed 15 in the in situ faunas) and Gen. Nov. aff. Dimeroceras appears in Bed 23 (Bed 14 in the in situ faunas). However the significance of these records is reduced because it is not wholly certain whence the specimens came.

No.	Bed	Marburg
2	25	Cheil. circumflexum (Sandberger and Sandberger)
14	25	Ch. pompeckji Wedekind
17	25	Torn. sp.
18	25	Ch. subpartitum (Münster)
19	25	Ch. subpartitum (Münster)
21	25	Ch. subpartitum (Münster)
33	25	Ch. subpartitum (Münster)
37	25	Paratorleyoceras umbilicatum (Sandberger and Sandberger)
41(ii)	23	Cheil. subpartitum (Wedekind)
42	23	Torleyoceras curvispina (Sandberger and Sandberger)
44	23	Gen. Nov. aff. Dimeroceras
70	21	Cheil. subpartitum (Münster)
86		Cheil. subpartitum (Münster)
89		Cheil. sacculum (Sandberger and Sandberger)
99		Cheil. planilobum (Sandberger and Sandberger)
113	13	Cheil. sacculum (Sandberger and Sandberger)

115	14	Cheil. pompeckji (Wedekind)
119	14	Cheil. aff. amblylobum (Sandberger and Sandberger)
131	13/12	Cheil. circumflexum (Sandberger and Sandberger)
142	13/12	Cheil. verneuili (Münster)
163	4/3	Sporadoceras biferum (Phillips)
165	2/1	Sporadoceras biferum (Phillips)

The few specimens obtained from Trench E, and the outcrops above, are most important for they allow a correlation to be made between the conodont and ammonoid zonation schemes in the lower Famennian. Unfortunately the Frasnian/Famennian boundary lies in either relatively unfossiliferous levels at the top of quarry F, or under the path which runs across between there and the trench.

Trench E

Schäfer (1978) provided conodont dates for the trench, and ammonoids were later collected from the same level. Unfortunately a 6.5m thick gap in the succession occurs in the middle of the trench between Beds 20 and 14.

Only one specimen (2211) could be identified from the lower part of the trench. This is a weathered example of Prot. cf. planidorsatum and was associated with an Upper crepida Zone fauna. Torleyoceras curvispina (2212) was collected from Bed 15, where there is no conodont date available, but Bed 14, immediately above, a distinctive dark red limestone, yielded Ch. circumflexum (2260), Ch. pompeckji (2216), Torl. curvispina (2217-8), Paratorleyoceras globosum (2219) and a rhomboidea Zone conodont fauna. Bed 14 also yielded a thickly discoidal carinate ventered goniatite identified as Paratornoceras sp. nov. cf. lentiforme sensu Petersen. This can be compared with Parat. lentiforme (2302) which is oxyconic from early whorls. It was collected loose at sample point 367, and may also come from this level since it has a similar matrix.

A number of specimens from this bed have been identified as

Gen. Nov. aff. Dimeroceras (2220,1,3). These differ from true Dimeroceras by having an umbilical lobe centred very near to the umbilical seam, and not on the flank, as illustrated by Wedekind (1908). The ventro-lateral lobe is situated very close to the shoulder and has a characteristic flexure on the ventrad slope, which precludes confusion with Cheiloceras. Petersen (1975) also reported forms like this from the Canning Basin.

All the faunas encountered up to this level would be placed in the curvispina Zone.

The earliest Sporadoceras were encountered in Bed 11; Sp. (Sp.) aff. biferum with a shallow adventive lobe in the lower part, and Sp. (Sp.) biferum in the upper part and in Beds 10 and 9. It is interesting to note that no Cheiloceras were collected in this, the most prolific part of the section and nor were any specimens collected with a broad adventive lobe bound by angular saddles, which could be identified as Maeneceras pompeckji, the index for the upper Cheiloceras Stufe zone. No ammonoids were collected from Beds 8-1. Beds 11-9 would be placed in the pompeckji Zone and Schäfer placed Beds 13-14 in the Lower marginifera Zone. Beds 4-1 are in the Upper marginifera Zone.

Outcrop C

The lowest part of outcrop A was dated by Ziegler (1962) as Upper marginifera Zone, so it is reasonable to assume that occurrence of Pseudoclymenia dillensis (2244), collected from outcrop C lying between there and the top of the trench, allows the equivalence of the Upper marginifera Zone and the sandbergeri Zone to be established.

Outcrop A

Ziegler (1962) identified five conodont faunas from Outcrop A, ranging from the Upper _marginifera_ Zone to the Middle _velifer_ Zone. It is not certain whether the top of Ziegler's section coincides with Bed 10 or Bed 1. It is a straight-forward section to measure and its base is clearly visible and not prone to erosion, and so measuring error is unlikely. Therefore, Ziegler's Sample 1 is correlated with the top of Bed 10 (see Textfig. 7.9).

Sporadoceras _posthumum_ (2248) and _muensteri_ (2250) were collected from Bed 45, and _Sp_. _inflexum_ (2251) from Bed 42. The earliest clymeniid was recorded from Bed 42 (2263). Unfortunately this level lies between Ziegler's Samples 8 (Lower _velifer_ Zone) and 9 (Upper _marginifera_ Zone) so precise correlation cannot be achieved. Further specimens were obtained from Beds 32/3 (2254-6, 64-5). An unidentifiable _Platyclymenia_ (2298) and Gen. Nov. _D_ _stuckenbergi_ were collected from Bed 25, in the Middle _velifer_ Zone.

The upper part of outcrop A (Beds 9-1), not sampled by Ziegler, but dated by Dreesen (see Chapter 6, Fauna 12) as Lower _styriacus_ Zone, yielded a large diverse fauna including, _inter_ _alia_, _Prionoceras_ _frechi_ and _Plat_. (_Plat_.) _richteri_. This level is considered to lie beneath that sampled by Lange 1929. Beds 9-1 are distinctive white-grey weathering biomicrites.

Sample point 353

Approximately 150m above Beds 9-1 (marked on Textfig. 7.2b as sample point 353) is a level which has obviously yielded many specimens to German amateur collectors, for they saw fit in the winter of 1979 to excavate a trench 1.5m wide and over 300m in length. Perhaps this was the horizon located by Wedekind and Lange. Specimens 2288-97 were obtained from here.

Outcrop J

A section at point J yielded fauna comprising _Plat_. (_Trig_.)

spinosa (2310,1), *Prionoceras divisum* and *Carinoclymenia*.

Sample point 352

Specimens of *Kosmoclymenia* were collected loose from the surface at sample point 352. Matrix from HU P82.14 yielded a Lower-Middle *styriacus* Zone conodont fauna. This level undoubtedly lies in the *Clymenia* Stufe, and it is overlain by lower Carboniferous lydites.

Bilsteinhöhle e5321 n9893, 4515 Hirschberg Pl. 7.4b, Textfigs. 7.5c,d

Faunas from this section, situated in an old shooting-range approximately 400m south east of the entrance to Bilsteinhöhle, 3km south west of Warstein, have recently been described by Clausen *et al*. (1979). Collections from silicified limestones made for this study largely confirm their conclusions. The following specimens, mostly internal moulds, were obtained:

Sample	Specimen Nos.	Age
79/124	77-79	*evoluta* Subzone
79/117	80-82	
79/122	83-84	*sphaeroides* Subzone
79/126	85-87	*paradoxa* Zone
79/129	89-93, 95-98	mid *Clymenia* Stufe - *paradoxa* Zone
79/128	94	
79/127	99-102, 106	
79/130	103-105	*sphaeroides* Subzone

Not all of the samples contained species sufficient for precise zonal discrimination. Important in this respect were: *Cyma.* cf. *evoluta* (79), *Wock*. *sphaeroides* (83, 105), *Para*. *paradoxa* (77, 93), *Gon.* (Subgen. Nov. *B*) *wocklumensis* (85, 94), *Imit*. *quadripartitum* (96).

Borke-Wehr e221 n186 4613 Balve Textfig. 7,12

This small quarry situated 300m north of point 241, 1.5km east south east of Balve, is the type locality of Para. paradoxa and lies on the slopes of the eponymous hill, Wocklum. A section through the Gattendorfia Stufe was given by Ziegler 1971a, below this lie 1.45m of Hangenberg Schiefer, with nodular limestones of uppermost Wocklumeria Stufe age below. A section is given in Textfig. 7.12b. Fauna collected includes:

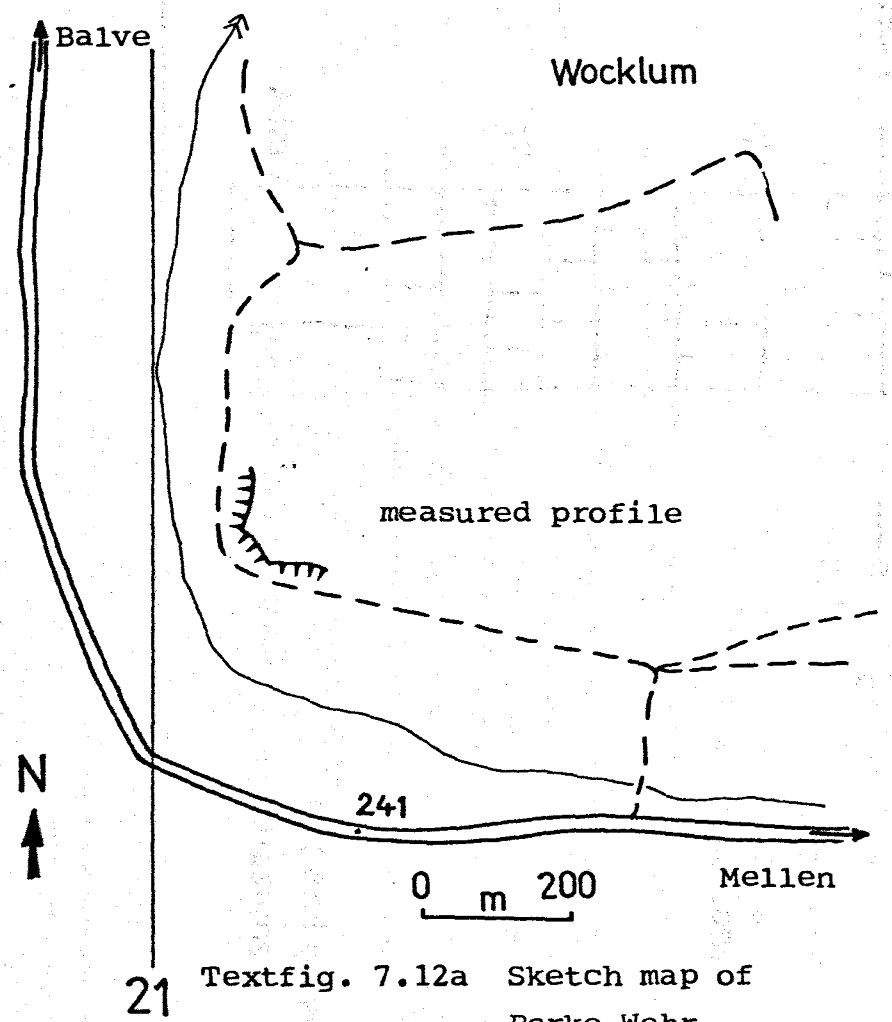
Bed	Specimen no.	Age
c	107-8	sphaeroides Subzone
b/d	109-10	paradoxa Zone

Dasberg e241 n950 4613 Balve Textfig. 7.13

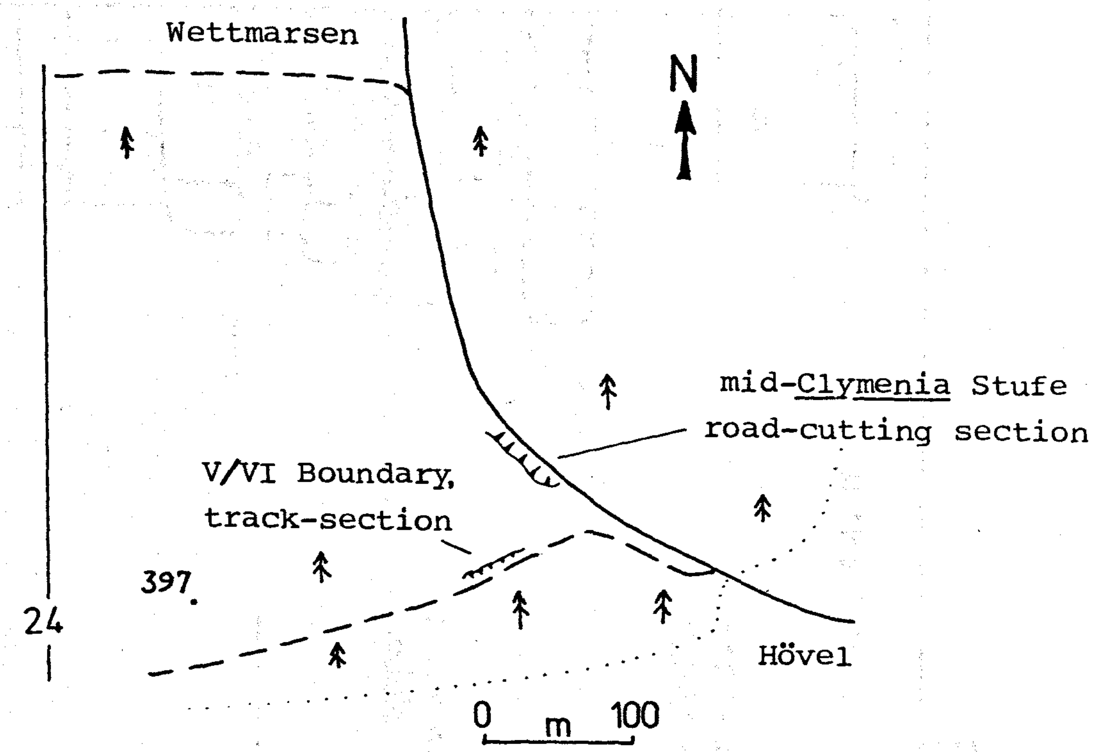
Schäfer (1978, p. 95) gave details of a trenched section through the upper Famennian at Dasberg, type locality for the Dasbergian. This trench was filled in some years ago, and the outcrops are no longer accessible. Two small outcrops yielded specimens. Near the roadside a cutting exposed mid-Clymenia Stufe age highly weathered white rubbly limestones, and numerous specimens of Cl. laevigata were collected. Small outcrops 70m along a track into the forest yielded a red-grey biomicrite including specimens of Gon. (Subgen. Nov. A) brevispina and Piri. piriformis.

Drewer e555 n710 4516 Warstein Pl.7.6a

Sections in this quarry formed the basis for Schmidt's (1921) biostratigraphic study. It is very difficult to collect faunas here today. Slumping in the northern wall is illustrated in Plate 7.6a.

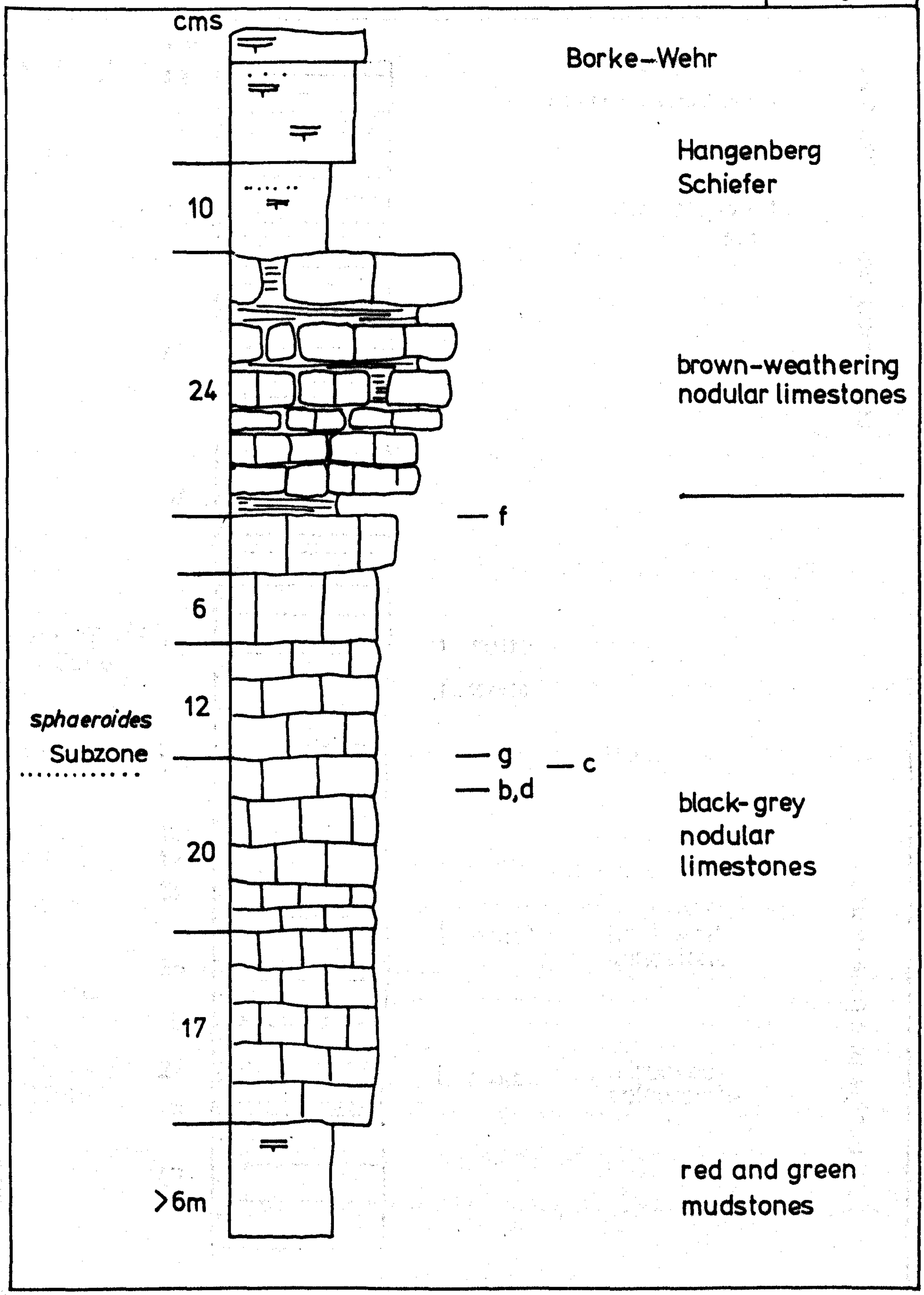


Textfig. 7.12a Sketch map of Borke-Wehr

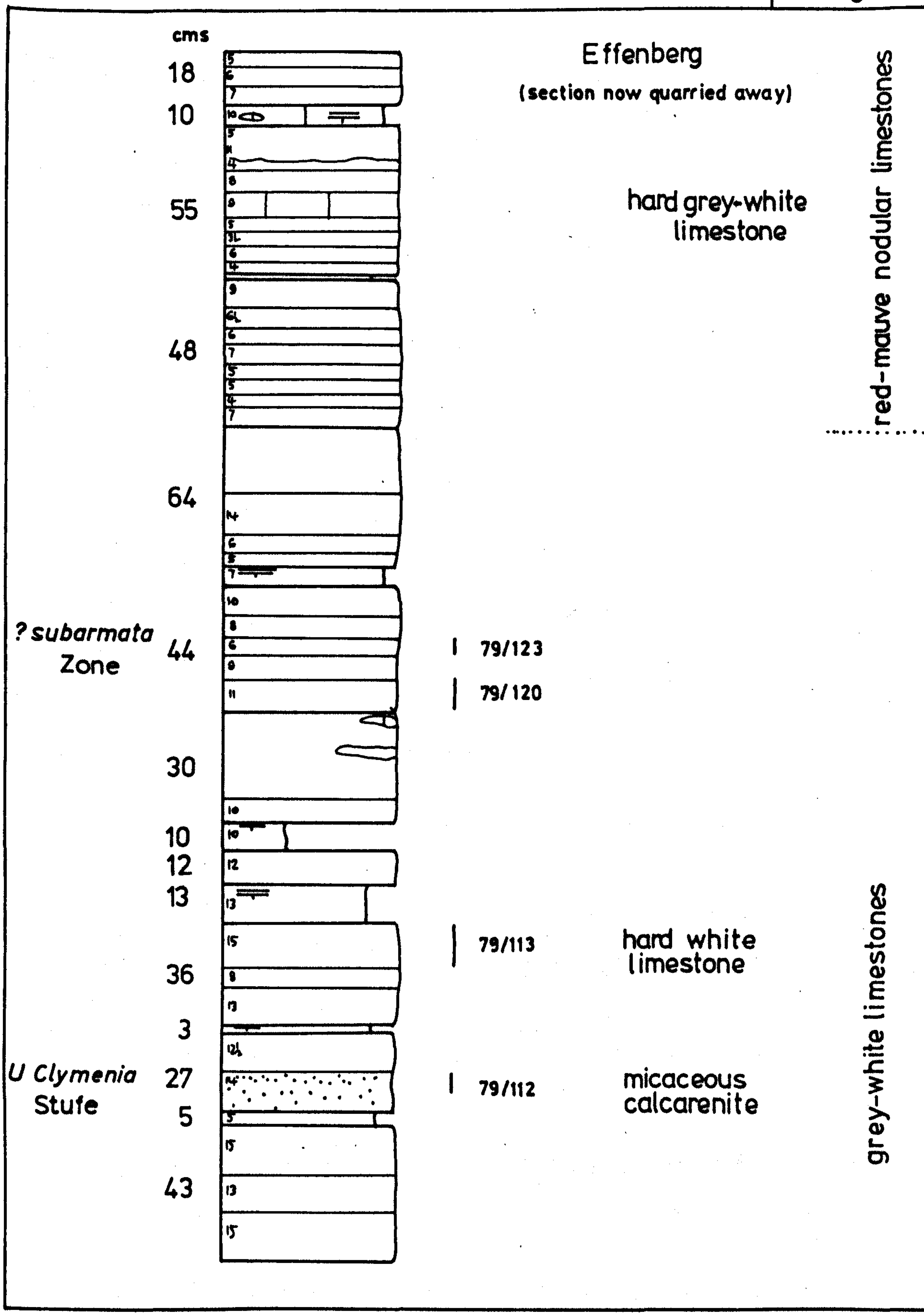


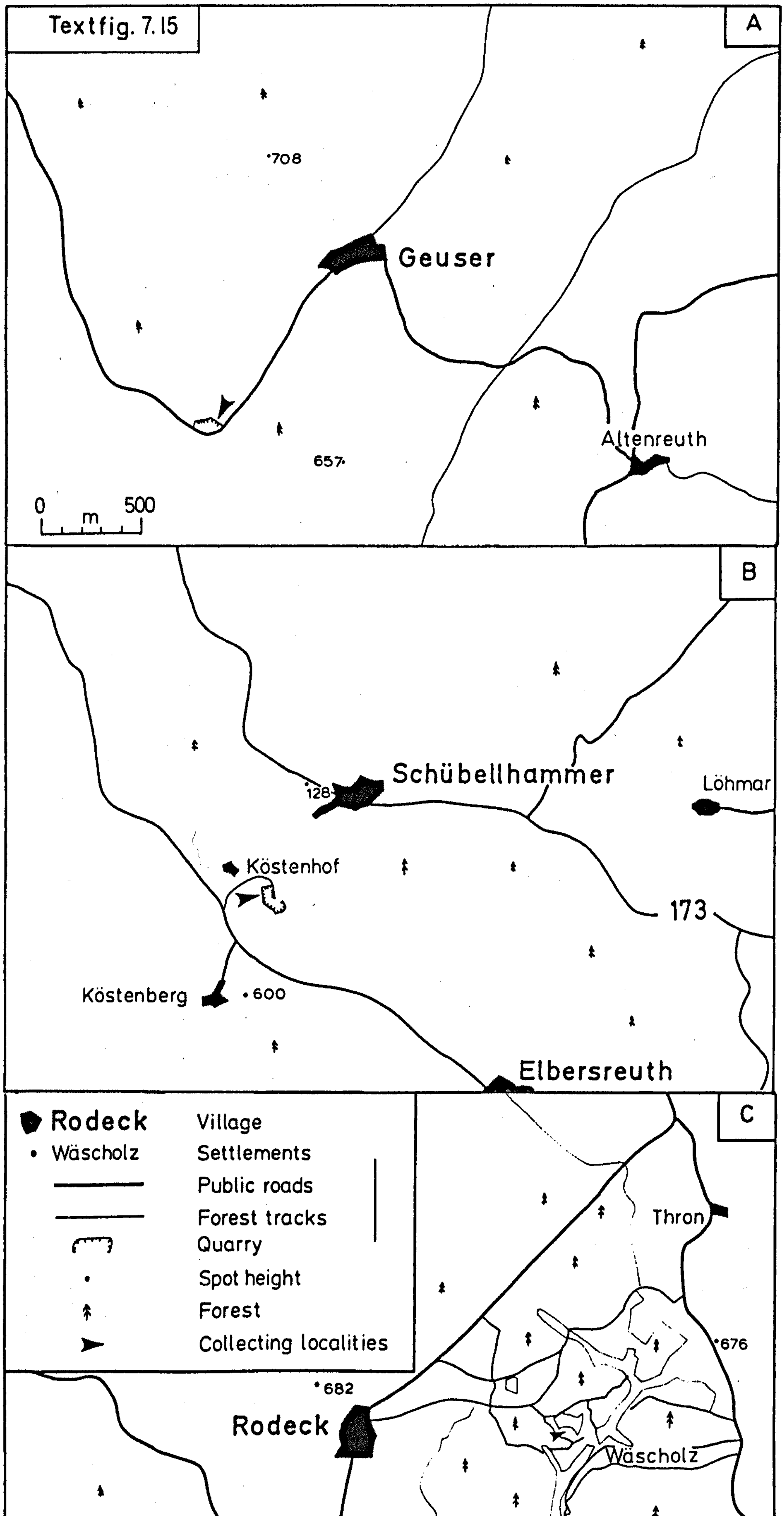
Textfig. 7.13 Sketch map of Dasberg

Textfig. 7.12b



Textfig. 7.14


Effenberg
(section now quarried away)
cms
18
10
55
48
64
44
30
10
12
13
36
3
27
5
43
? subarmata Zone
U Clymenia Stufe
79/123
79/120
79/113
79/112
hard grey-white limestone
hard white limestone
micaceous calcarenite
red-mauve nodular limestones
grey-white limestones



Textfig. 7.15
A
708
Geuser
Altenreuth
657
0 m 500
B
Schübellhammer
128
Löhmar
Köstenhof
173
Köstenberg
600
Elbersreuth
C
Rodeck Village
Wäscholz Settlements
Public roads
Forest tracks
Quarry
Spot height
Forest
Collecting localities
Thron
676
682
Rodeck
Wäscholz

Effenberg e277 n957 4613 Balve Textfig. 7.14

A profile for this section is given in Textfig. 7.14. Grey-red upper Famennian nodular limestones form the overburden in an active quarry exploiting massive Lower Famennian limestones. Consequently no map is given, and the section has now been destroyed.

Faunas were collected from three levels, and included the following:

Sample	Specimen No.	Age
80/123	112-14, 2056-60	?subarmata Zone
80/120	115, 116	
80/112	117-23, 2055	upper Clymenia Stufe

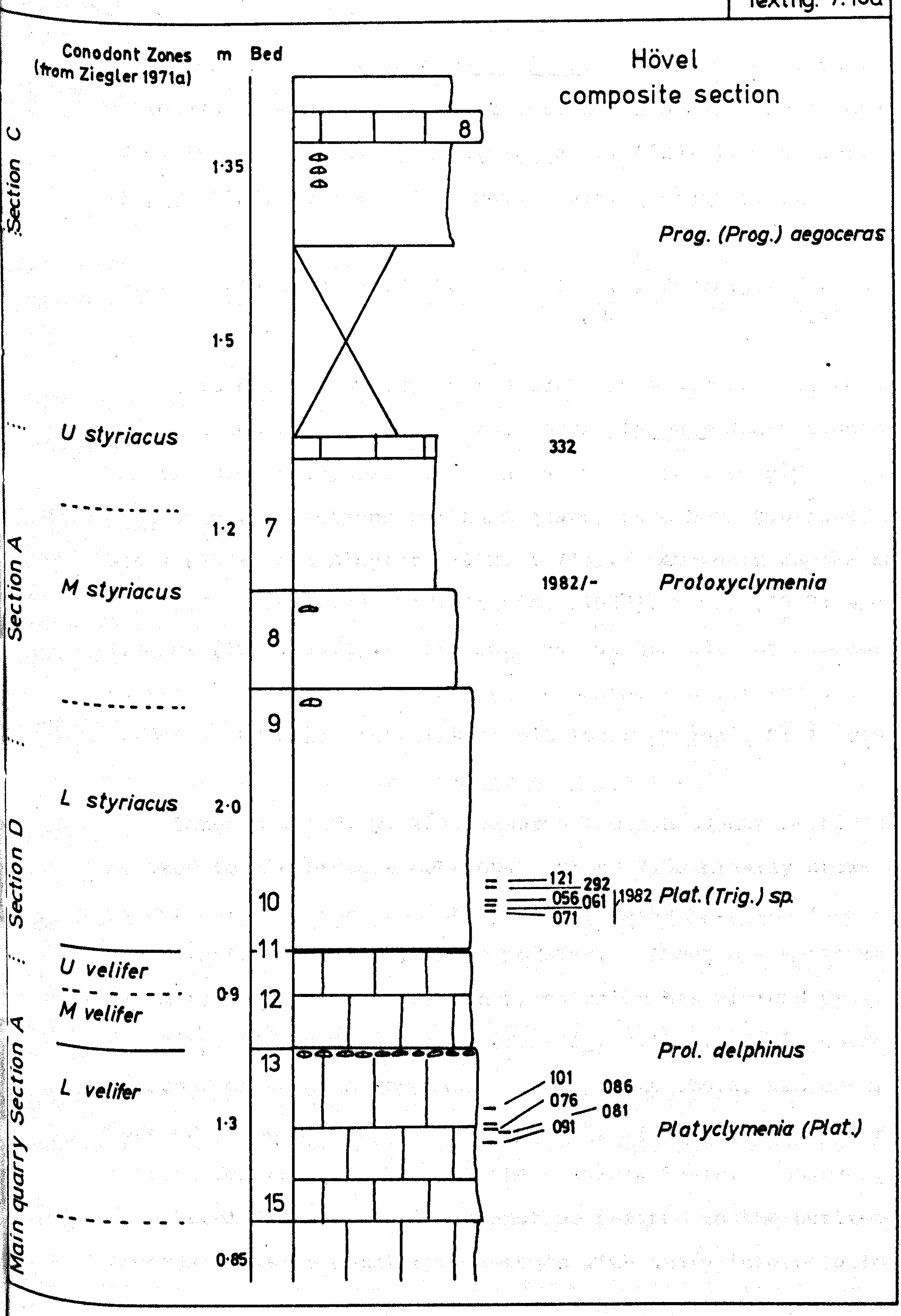
The most distinctive fauna comes from sample 79/112, and includes an undescribed species of Kosmoclymenia (117) (= effenbergensis, Korn and Price, in preparation), also encountered in Bed 9 at Hövel.

Geuser e615 n668 5734 Wallenfels Textfig. 7.15A

Approximately 20m of grey massive Upper Devonian limestones are exposed in a disused quarry south west of the hamlet of Geuser, 4km south of Wallenfels, Frankenwald. At the top of the quarry, in a dangerous position which precluded accurate measurement of the section, are approximately 50cms of thinly bedded grey limestones, from which a large fauna was collected. Gümbel (1863, p. 112) mentioned a locality "Fundorte vom Grafen zu Münster... beidem Dorf Geiser im oberen Zeyernbach-Thälchen", which description fits this quarry. It is interpreted as Münster's locality "Geiser".

The fauna comprised numerous specimens of Pseudoclymenia (131-69) including Ps. sedgwicki (Münster), which hitherto has

Textfig. 7.16a

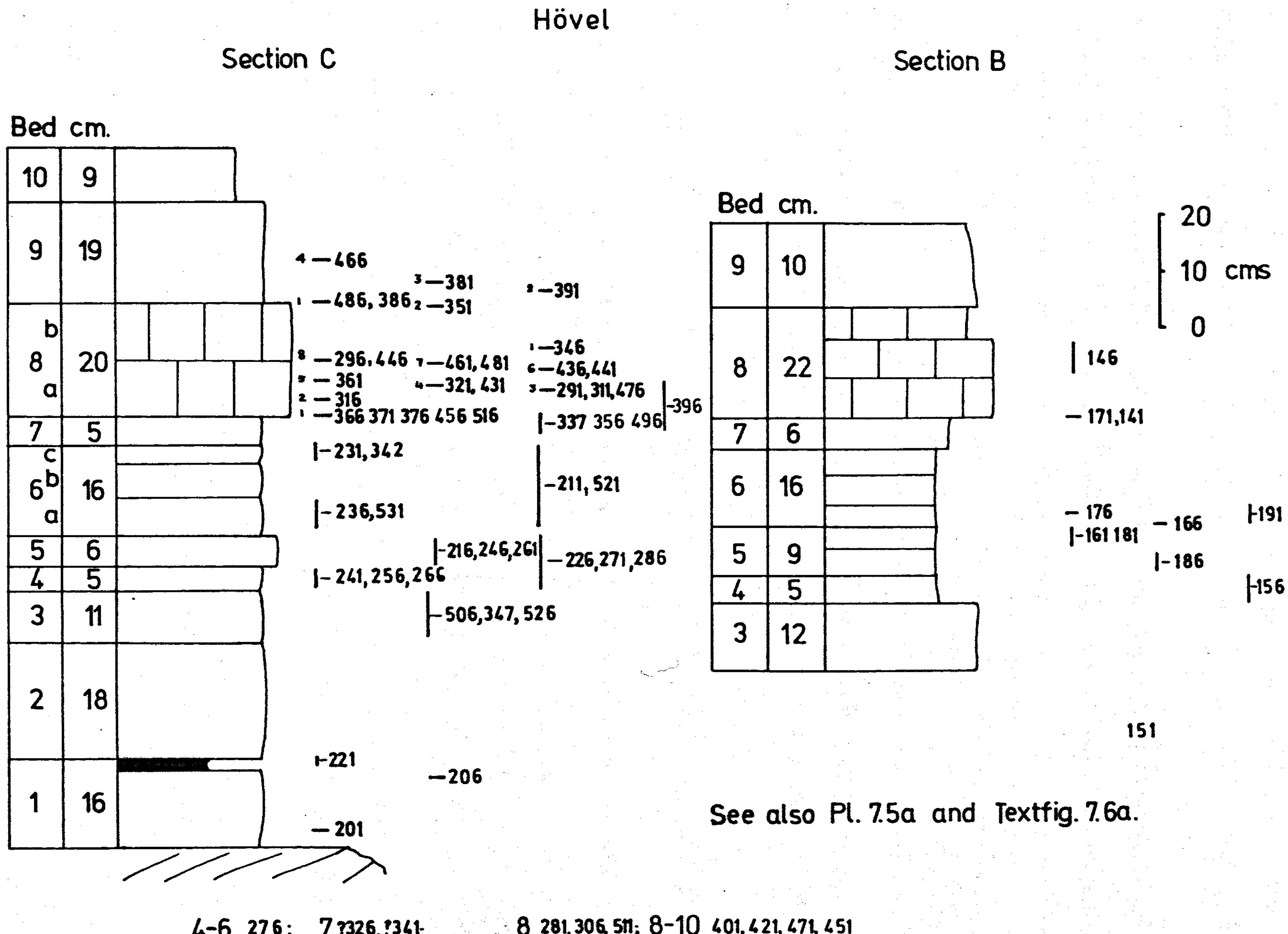


has been recognised as a Kosmoclymenia. Matrix from these specimens (378) yielded a marginifera Zone conodont fauna. Also collected from here were, what must on this evidence be considered as early, clymeniids: Platyclymenia sp. (124-6), Gen. Nov. D kayseri (129, 130) and Gen. Nov. F aff. costata (21).

Hövel e246 n923 4613 Balve Pl. 7,5, Textfigs. 7.6a-d, 7.16a,b, 7.17

This disused quarry on the B229 1km south west of Hövel is the most important locality for lower Clymenia Stufe faunas. The limestones exposed range in age from the marginifera to ?costatus Zones. Sections for this quarry have been published by Lange (1929) and Ziegler (1962, 1971a). Ammonoid faunas have been reported by Wedekind 1914, Schmidt (1924), Lange (1929) and Ziegler (1962, 1971). The horizon of the bulk of ammonoid material collected from here (by Wedekind and Torley) was not recorded. Wedekind established his lower Clymenia Stufe division here, characterised by Clymenia hoevelensis.

Lange's (1929, p. 26) measured section cannot be directly related to the present outcrop. Plate 7.5b clearly shows a marker horizon, the Annulata Shale. Below this the limestones are relatively massive, above nodular. About one metre below the Annulata Shale is a nodular horizon which has yielded Prol. delphinus and Cyrt. involuta (Textfig. 7.16a). This corresponds to Bed 2 of Lange's account. Bed 3, next above, was described as "grauer dickbankiger flaseriger Kalk", 1.1m in thickness, which is fitting for the unit beneath the Annulata Shale. However, above this level Lange's section cannot be related to the outcrop. He records 20cms of nodular limestones with shaly intercalations (Beds 4,5) overlain by 70cms of relatively massive grey limestones



See also Pl. 7.5a and Textfig. 7.6a.

(Bed 6-7). The following fauna was recorded: Bed 4: End. (Cost.) kiliani; Bed 5: Cl. laevigata; Bed 6: Cl. laevigata, Prog. (Prog.) aegoceras, Gon. (Gon.) subcarinata; and Bed 7: "Oxy. sedgwicki". Beds 5-7 are most probably equivalent to the limestone exposed at Section C, (see below).

Main Quarry Section A   Pl. 7.5b, Textfigs. 7,6d, 7.16b

For this study Plat. (Plat.) pompeckii (sample 081; 188/9) and Sp. (Sp.) muensteri (sample 076; 176) were collected from an horizon 1.40m below the Annulata Shale, a level dated as Lower velifer Zone (Ziegler 1971a), and represents the earliest dated in situ occurrence of clymeniids.

Section D

A level 40cms above the Annulata Shale (Section D) yielded Plat. (Plat.) cf. valida sensu Drevermann (1908), Plat. (?Trigonoclymenia) sp. (2371) and Posttornoceras sp. (2368). This level was dated as Lower styriacus Zone by Ziegler (1971a) and represents the highest known in situ record of an annulata Zone fauna. From 15cms (sample 056) above this level a small smooth clymeniid, identified as cf. Cl. spiratissima (1910) was collected. The highest exposures in the main part of the quarry (immediately below Section C) yielded Protoxyclymenia sp., and presumably fall in the Upper styriacus Zone (Ziegler 1971a).

Section C   Pl. 7.5a, Textfigs. 7.6a, 7.16b

Above the main quarry an exposure of 1.35m of massive grey limestones of Clymenia Stufe age was excavated. Twenty faunal levels were recorded. Significant records were as follows:

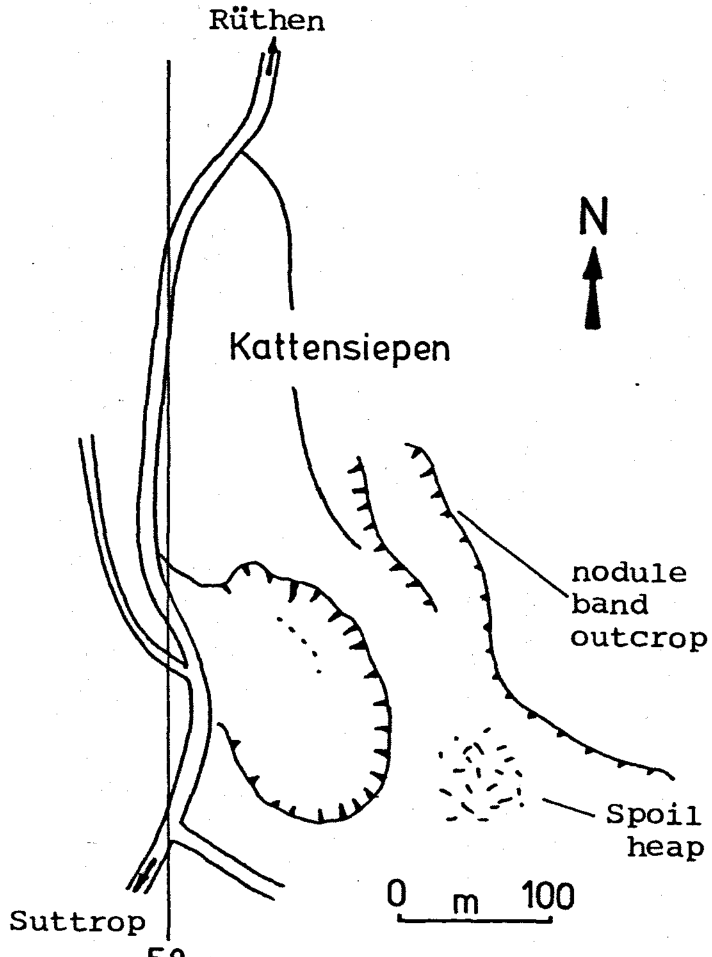
Bed	Sample	Specimen	Species
1	206	1940	Gen. Nov. D cf. acuta sensu Schmidt
6	331	1948	Prog. (Prog.) aegoceras

6	521	1974	Kosmo. subundulata
		2044	Sell. aff. plana
		2045	Cyma. costellata
6c	231	1980	Cl. laevigata
7	496	1981	Gon. (Gon.) hoevelensis
7	496	1988	Kosmo. aff. inaequistriata
8a	291	1997	Cyma. cf. tricarinata
8a	311	2019	Kosmo. inaequistriata
8b/9	351 or	2032	Prog. (Prog.) aegoceras
	386	2033	Cl. laevigata
		2034	Sell. torleyi
9	381	2024	Kosmo. effenbergensis (Korn and Price, in preparation).
9	391	2028-30	Cyma. aff. striata

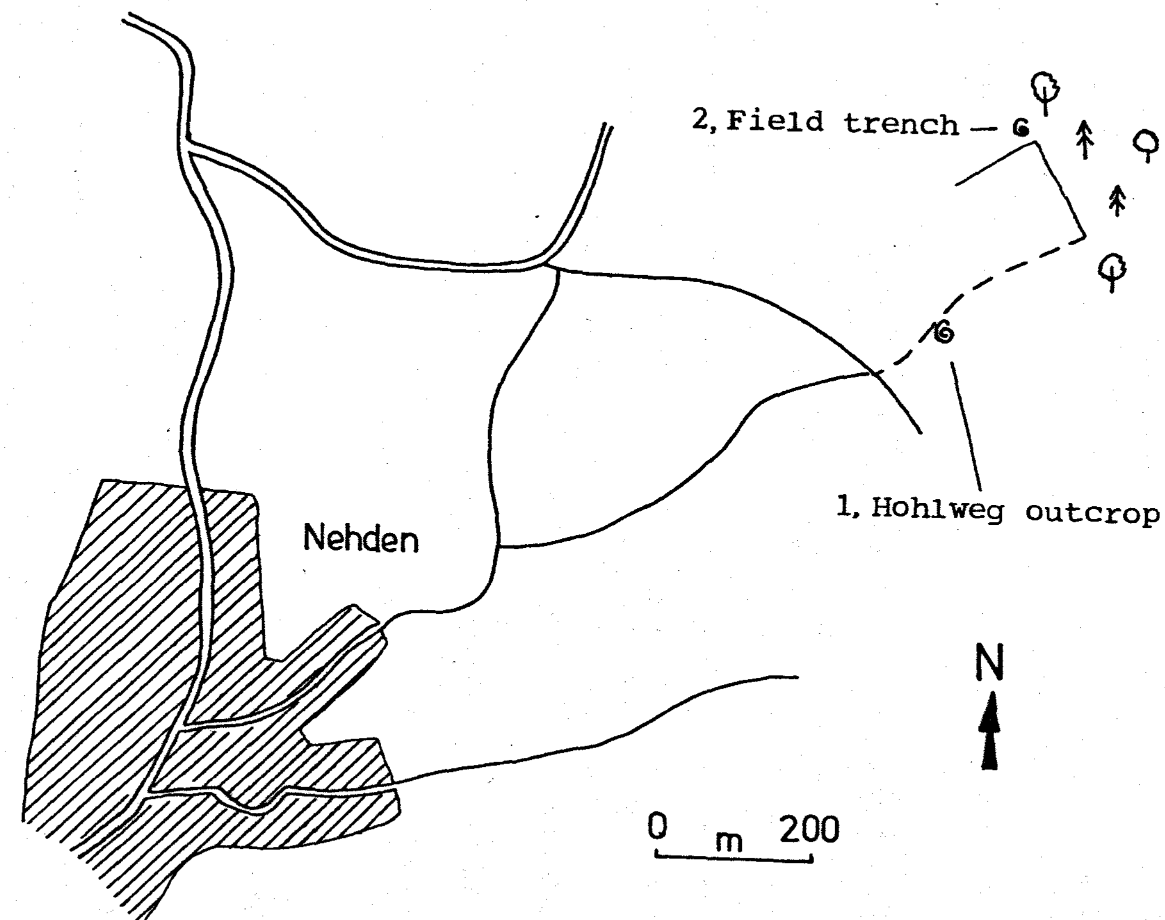
A notable absentee from this list is End. (Cost.) kiliani which Lange (1929) recorded as abundant in the lower Clymenia Stufe at Hövel. Presumably it would be found in the unexposed part of the section, between the main quarry and Section C. Clymenia laevigata is present in Bed 2 near the base of the section and ranges at least as high as Bed 6c, being particularly abundant in Beds 5 and 6. The single record from Bed 8b/9 (sample 351/386) is circumspect, and especially so since the correct sample number is not certain.

Kosmoclymenia subundulata was recorded from Bed 6, but ranges lower (Korn pers. comm.). Kosmoclymenia aff. inaequistriata (= Oxy. elegantula sensu Schmidt) with relatively coarse growth-lines ranges upwards from Bed 7, Kosmo. inaequistriata appears in Bed 8a, and an as yet undescribed species with regular coarse radial growth-lines enters the record in Bed 9.

Other genera and species are not sufficiently common for ranges to be stated with any degree of certainty. Particularly rare was Gon. (Gonioclymenia) of which only three in situ examples were found. However, since there is no published accurately



Textfig. 7.18a Sketch map of Kattensiepen



Textfig. 7.18b Sketch map of Nehden

measured section through the *Clymenia* Stufe, this contribution is particularly important, even though neither its upper nor lower boundaries can be defined.

Kattensiepen e579 n036 4516 Warstein Textfig. 7.18a

This large disused quarry lying between Rüthen and Suttrop exposes a sequence of 70m of limestones ranging from the *crepida* Zone to the *anchoralis* Zone. Particularly important is a nodular bituminous limestone considered to be a lateral equivalent of the Annulata Shale. It contains a rich fauna of *Platyclymenia*, *Prionoceras*, *Posttornoceras* and *Prolobites*. Over 500 specimens are known from this level but, interestingly, neither *Cyrtoclymenia* *Cymaclymenia* nor *Sporadoceras* have been found.

Nehden Hohlweg e758 n005 4517 Alme Textfig. 7.18b

Many thousand specimens of *Cheiloceras* have been collected from this classic locality (Textfig. 7. 18b) where the 20m thick Nehden Schiefer crop out. Most of these specimens have come from fields south east of the village of Nehden, and from Hohlweg in the north east, where a stream cutting exposes ca 5m of black-grey silty shales. From one horizon here over 100 examples of *Paratorleyoceras* *umbilicatum* and 30 examples of *Cheiloceras* "*acutum*" (*sensu* Sandberger and Sandberger) were collected. A representative fauna from here has been lodged in the Hull Collections (2193-2201). The Nehden Schiefer appear entirely lower *curvispina* Zone in age, since no *Paratornoceras* have been found.

Oberrödinghausen

Railway-cutting   e194 n961   4613   Balve

This is the locality from which Schindewolf (1937a) collected a large fauna, including at least 900 specimens of Wocklumeria sphaeroides. Such collecting is not possible today, especially at outcrop. A number of unweathered blocks, labelled with Schindewolf's (1937a) bed numbers, have been deposited in the Departmental Collections at Hull.

B515 road-cutting   e197 n964   4613   Balve

Until it was cleared for the IUGS Devonian/Carboniferous boundary Working Group in the Summer of 1982, all that remained of the section described by Ziegler (1962) were a few metres of nodular limestones lying immediately below the Hangenberg Schiefer.

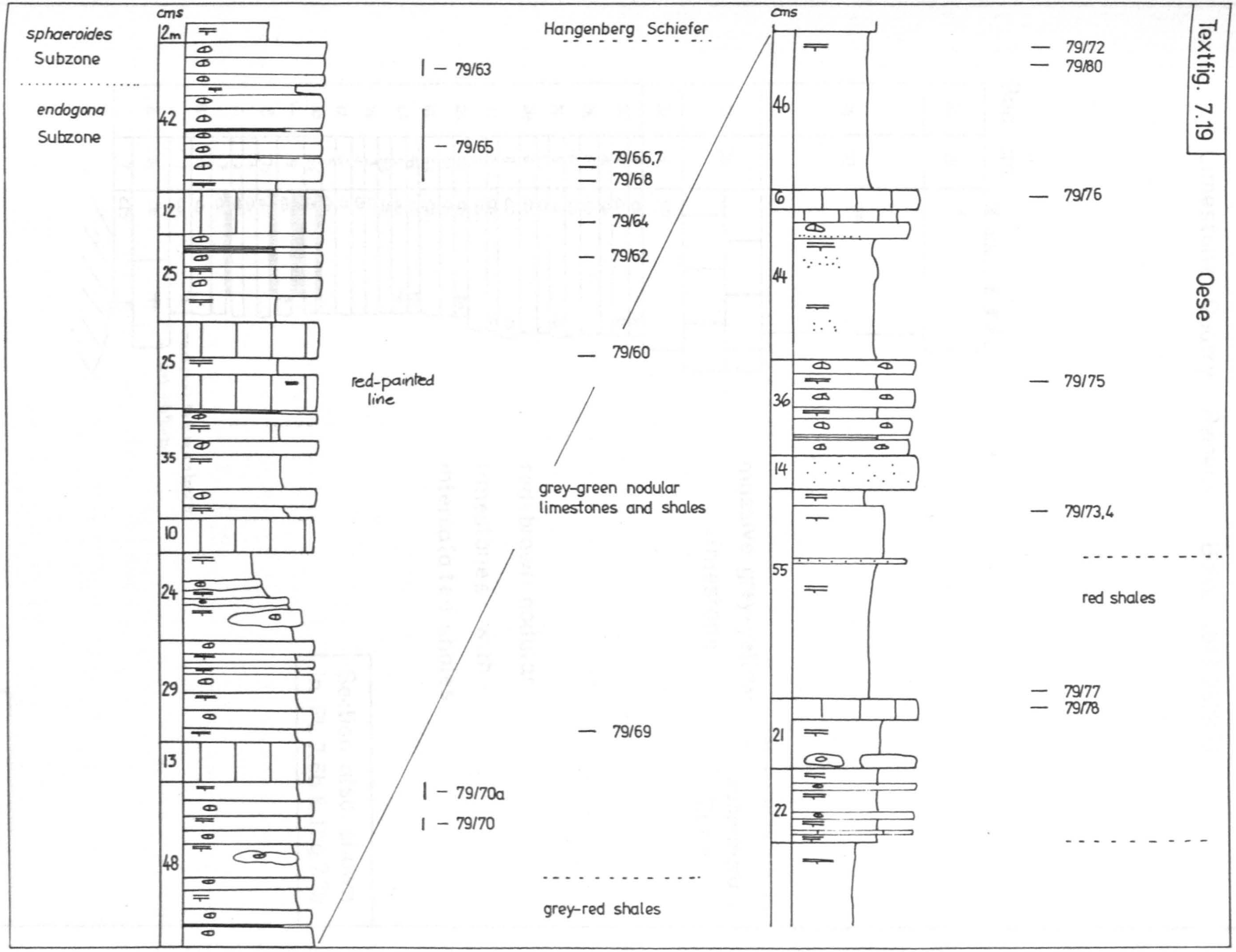
Two samples were collected in situ, and their horizon is correlated with Ziegler's (1962) Sample 16, subarmata Zone.

Oese   e157 n969   4512   Menden   Textfig. 7.19

A 400m long road-cutting on the western side of the B7, just south of the railway Haltepunkt Oese, exposes a thick sequence of interbedded Famennian sandstones, siltstones and shales with nodular uppermost Devonian limestones occurring beneath the Hangenberg Schiefer. A detailed section was given by Ziegler (1962), and the upper portion of this is covered by Textfig. 7.19.

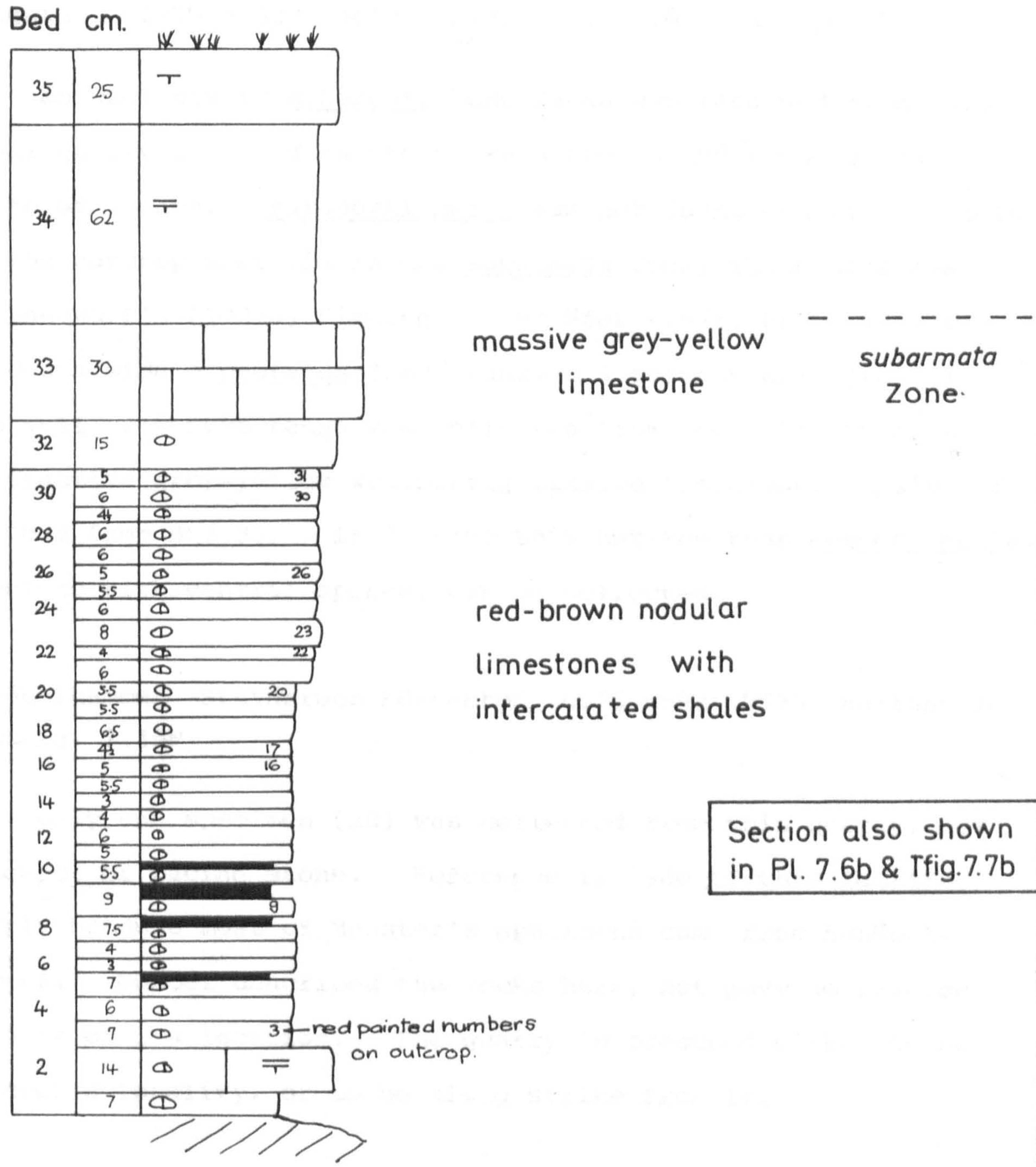
Most specimens were collected from the uppermost 5m of the sequence, dated as Wocklumeria Stufe. However, flattened Platyclymenia were recovered from 45cms thick grey/black shales, (Bed 25 of Ziegler's account), some 12.35m below the base of the Hangenberg Schiefer (79/87-9, 2089-96).

The following finds were significant:


cms
sphaeroides
Subzone
endogona
Subzone
2m
42
12
25
25
35
10
24
29
13
48
red-painted line
79/63
79/65
79/70a
79/70
Hangenberg Schiefer
79/66,7
79/68
79/64
79/62
79/60
grey-green nodular limestones and shales
79/69
grey-red shales
cms
46
6
44
36
14
55
21
22
79/72
79/80
79/76
79/75
79/73,4
red shales
79/77
79/78
Oese

Textfig. 7.19

Limestone Quarry Reigern Balve 4613:297953



Section also shown in Pl. 7.6b & Tfig. 7.7b

Textfig. 7.20

Wocklumeria sphaeroides (79/63; 2116), Parawocklumeria paradoxa (79/65; 2111/2), and Imitoceras cf. quadripartitum (79/77; 2097) collected from 4.6m below the Hangenberg Schiefer, the lowest level which can be included within the subarmata Zone.

Reigern e2979 n9528 4613 Balve Pl. 7.6, Textfigs. 7.7, 7.20

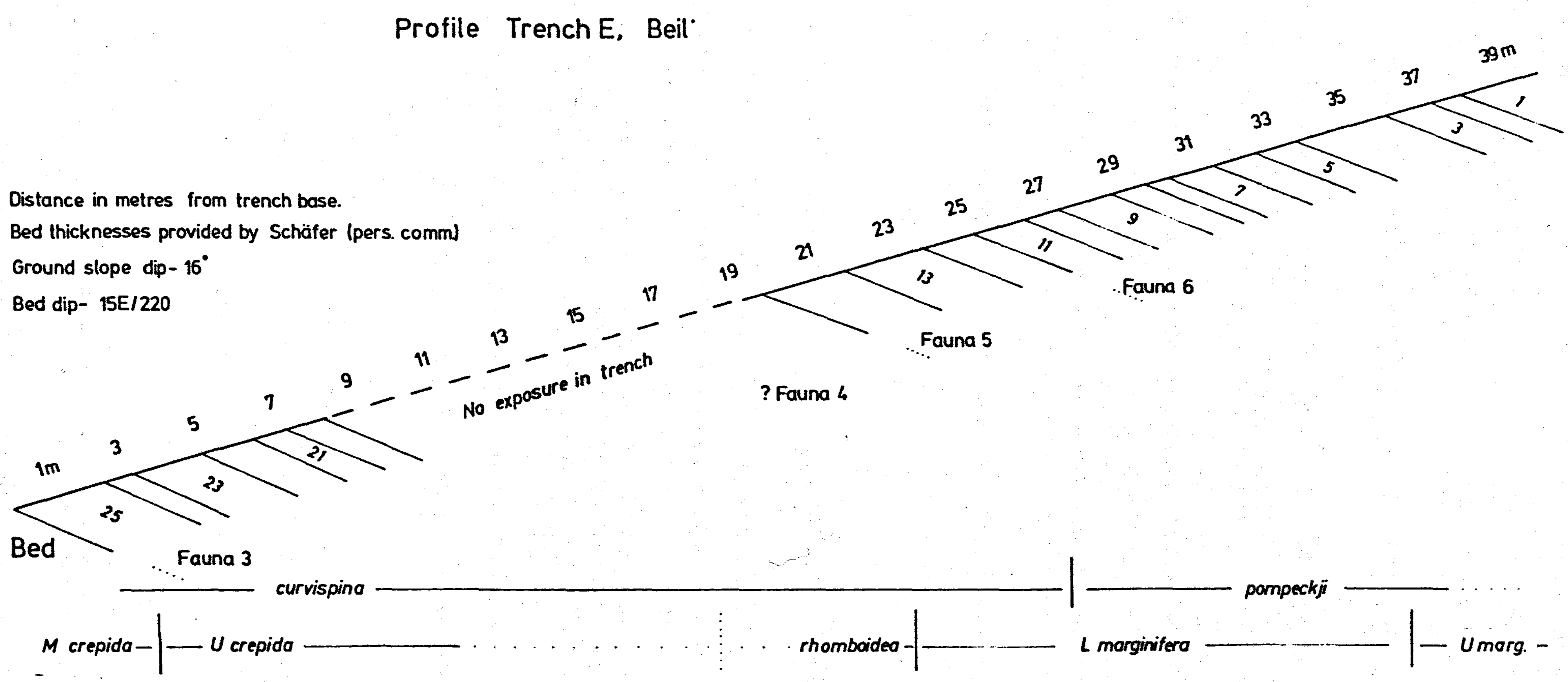
An exclusively subarmata Zone fauna was recorded from this small quarry situated on the south slopes of Müssenberg, just north of Hachen. Parawocklumeria was not found and so the whole of the outcrop must lie in the subarmata Zone, which confirms Schindewolf's (1937a) findings. Schäfer (1978, Probe 184) recorded a middle costatus Zone fauna. A particularly prolific and well preserved fauna was collected from loose blocks of a distinctive grey-yellow weathering massive limestone, considered to come from Bed 33. It is from this horizon that Kosmoclymenia, complete with ventral spines, can be collected.

Schübelhammer Steinbruch Köstenhof e675 n692 5735 Wallenfels Textfig. 7.15B

Only one specimen (20) was collected from this quarry, now a source of facing stone. Reference is made to this locality simply because most of Munster's specimens came from Schübelhammer. Gümbel described the rocks here, but gave no precise details of its location. The quarry is presumed either to be Munster's locality, or to be along strike from it.

Wäschholz e752 n699 Schwarzenbach am Wald Textfig. 7.15C

This locality can be described only as in the middle of the forest, three kilometres south east of Schwarzenbach am Wald,



Textfig. 7.21 Chart showing conodont zones and faunal horizons/zones based on ammonoids in Trench E at Beil, used to relate material found loose to outcrop.

Frankenwald (Textfig. 7.15A). Collecting was possible only from loose blocks but information for this Bavarian locality is included because a fauna was obtained which is partially unknown in the Rheinische Schiefergebirge. Co-occurring with Platyclymenia (Plat.) and Plat. (Trigonoclymenia) were Aktuboclymenia (2208), cf. Protoxyclymenia (2207) and examples of an undescribed genus (2202-6). These examples are small (D < 2cms) and highly evolute with a compressed whorl-section and distinctive biconvex prorsiradiate ribs on the last whorl (except for 2206). Unfortunately sutures were not visible on these, nor on the Aktuboclymenia, which would confirm the only other recorded occurrence of this genus outside the Urals.

Appendix 1

Specimens deposited in the collections of the University of Hull

All specimen numbers are preceded by HU P82.
Sample numbers are listed in Appendix 2

Illustrated Specimens

No.	Samp.	Name	Illustration
1	388/3	Sulco. sulcata (Schindewolf), Geuser	Pl. 5.19, Figs. 14,15
2	403/6	Sulco. aff. sulcata (Schindewolf), Wäschholz	Pl. 5.19, Fig. 18
3	79/29	Plat. (Plat.) richteri (Wedekind), Ainkhausen	Pl. 5.13, Figs. 1,3,4, 5,8,12
4	-	Cyrt. involuta (Wedekind), Beringhausen	Tf. 17E
5	-	Cyma. sp. a, Effenberg	Pl. 5.39, Figs. 4-6 Tf. 5.33L,M
6	396/2	Plat. (Plat.) richteri (Wedekind), Wäschholz	Pl. 5.13, Fig. 2
7	? Bed 33	Kosmo. undulata (Münster), Reigern	Pl. 5.22, Fig. 10, Tf. 27E
8	142	Kosmo. inaequistriata (Münster), Müssenberg	Pl. 5.21, Figs. 1,2
9	? Bed 33	Kosmo. undulata (Münster)	Pl. 5.21, Figs. 3,8
10	400-500	Kosmo. inaequistriata (Münster), Hövel	Pl. 5.21, Figs. 4,5,7, Pl. 5.23, Fig. 10
11	? Bed 33	Kosmo. undulata (Münster), Reigern	Pl. 5.22, Fig. 5 Tf. 27D
12	-	Kosmo. bisulcata (Münster), Reigern	Pl. 5.26, Figs. 14-16 Tf. 29B
13	-	Kosmo. subundulata (Wedekind), Hövel	Pl. 5.28, Figs. 3,6
14	352	Kosmo. subundulata (Wedekind), Beil	Pl. 5.29, Figs. 1-3
15	352	Kosmo. sp., Beil	Pl. 5.29, Figs. 4-6
16			
17	-	Cyma. sp.	Pl. 5.38, Fig. 17
18	-	Cyma. sp.	Tf. 5.31G-I
19	-	Cyma. sp.	Tf. 5.31F
20	408	Cyma. camerata Schindewolf, Schübelhammer	Pl. 5.42, Figs. 1,2
21-2		see below, after specimen 49	
129	348/1	Gen. Nov. D kayseri (Drevermann), Geuser	Pl. 5.31, Fig. 8

Casts

No.	Name
23	Plat. (Plat.) prorsostriata Schindewolf see Pl. 5.16, Fig.4
24	Plat. (Plat.) quenstedti Wedekind see Pl. 5.13, Figs. 6,7
25	Pr. serpentina (Münster) see Pl. 5.26, Figs. 10,11
26	Kosmo. sp. d see Pl. 5.25, Figs. 15,16
27	Sulco. sulcata (Schindewolf) see Pl. 5.19, Fig. 16
28	Gen. Nov. D flexuosa (Münster) see Pl. 5.31, Fig. 1
29	Gen. Nov. F aff. costata (Münster) see Pl. 5.30, Fig. 5
30	Gen. Nov. F ? decorata (Münster) see Pl. 5.30, Fig. 8
31	Gen. Nov. F aff. subflexuosa (Münster) see Pl. 5.30, Fig. 9
32	Gen. Nov. D kayseri (Drevermann) see Pl. 5.31, Fig. 7
33	Gen. Nov. E sp. b see Pl. 5.31, Fig. 3
34	Plat. (Trig.) spinosa (Münster) see Pl. 5.17, Figs. 5,6
35	Genu. borni (Schindewolf) see Pl. 5.36, Fig. 2
36	Genu. borni (Schindewolf) see Pl. 5.36, Fig. 1
37a	Cyma. striata (Münster) see Pl. 5.37, Fig. 7
b	Cyma. striata (Münster) see Pl. 5.37, Fig. 10
38	Cyma. camerata (Münster) see Pl. 5.37, Fig. 14
39	Cyclo. planorbiformis (Münster), cast of SM H10375, proposed neotype. Münster Collection, Gattendorf.

Conodont faunas

No.	Sample	Explanation
40	-	Nodule Band, Kattensiepen
41	D	Beds 1-10, outcrop A, Beil
42	-	Cycloclymenia clymenioides, holotype, UEN
43	378	Geuser (horizon with Ps. sedgwicki)
44	-	Outcrop C1, Beil (matrix from 2244)
45	-	Bed 9f, Trench E, Beil
46	-	Bed 11g, Trench E, Beil
47	-	Bed 15a, Trench E, Beil
48	-	Sample point 2, Nehden
49	-	Sample point 2, Nehden

Other specimens

No.	Sample	Name and Locality
21	308	Gen. Nov. aff. costata (Münster), Geuser
22	-	Cl. laevigata (Münster), Dasberg road-cutting

Ainkhausen

Sample	No.	Name
79/2	51-5	Prionoceras divisum (Münster)
	56-8	Prionoceras sulcatum (Münster)
	59	Prionoceras frechi (Wedekind)
	60	Prionoceras divisum (Münster)
	2081	Prolobites delphinus (Sandberger)
79/23	61	Plat. (Plat.) richteri Wedekind
	62	Protoxyclymenia sp.
	63	Plat. (Plat.) beuelensis Lange
	64-9	Plat. (Plat.) sp.
	70	Plat. (Trig.) spinosa (Münster)
	71	? Clymenia or Gen. Nov. sp. nov.
79/25	72-4	Prionoceras frechi (Wedekind)
	75	Prionoceras cf. frechi (Wedekind)
	76	Plat. (Plat.) richteri Wedekind
76/29	3	Plat. (Plat.) richteri Wedekind

The fauna recovered from Ainkhausen comes from a loose block considered to be equivalent to lower part Bed 2 (Textfig. 7.8). It can be dated only as annulata Zone.

Bilsteinhöhle

124	77	Parawocklumeria paradoxa (Wedekind)
	78	Kosmoclymenia similis (Münster)
	79	Cymaclymenia cf. evoluta (Schmidt)
117	80	Kosmo. sp.
	81	Kosmo. sp.
	82	indet.
122	83	cf. Wocklumeria sphaeroides (Richter)
	84	Imitoceras sp.
126	85a,b	Gon. (Subgen. Nov. B) wocklumensis (Lange)
	86	Gon. (Subgen. Nov. B) wocklumensis (Lange)

	87	Kosmo. sp.
125	88a,b	Kosmo. sp.
129	89	? Cl. laevigata (Münster)
	90	Cl. laevigata (Münster)
	91	indet.
	92	indet.
	93	Para. paradoxa (Wedekind)
128	94	Gon. (Subgen. Nov. B) aff. wocklumensis (Lange)
129	95	Kosmo. cf. undulata (Münster)
	96	Imitoceras cf. quadripartitum (Münster)
	97	Imit. sp.
	98	Kosmo. sp. and Imit. sp.
127	99	Kosmo. sp.
	100	Kosmo. sp.
	101a-d	Kosmo. sp.
	102a-d	Kosmo. sp. Note the body-chamber constriction.
130	103	Kosmo. sp.
	104	Imitoceras sp.
	105	? Wock. sphaeroides (Richter)
127	106	Kosmo. sp.

Borke-Wehr

c	107	Wock. sphaeroides (Richter)
	108	Para. paradoxa (Wedekind)
b&d	109	Cyma. sp.
	110	Para. paradoxa (Wedekind)
-	111a,b	Wock. sphaeroides (Richter)

Effenberg

123	112a,b	Cyma. costata (Münster)
	113	Kosmo. colubrina (Lange)
	114	indeterminate clymeniids
120	115	Sporadoceras sp.
	116a,b	Kosmo. sp.
112	117	Kosmo. effenbergensis (Korn and Price in prep.)
	118	phacopid
	119	Cyma. sp.
	120	Cyma. sp. a

	121	*Kosmo.* aff. *sublaevis* (Münster)
112	122	*Kosmo. colubrina* (Lange)
	123	*Kosmo. inaequistriata* (Münster)
	2055	*Cyrto.* sp.
123	2056	*Kosmo.* cf. *inaequistriata* (Münster)
	2057	*Cyma.* sp.
	2058	phacopid
	2059	*Cyma.* sp.
	2060	phacopid

Geuser

378	124	? *Platyclymenia* sp.
388/9	125	*Platyclymenia* sp.
383	126	*Platyclymenia* sp., cross-section
-	127	Platyclymenia sp.
378	128	*Ps. sedgwicki* (Münster)
348	129, 130	Gen. Nov. *D kayseri* (Drevermann), illustrated.
288	131	*Pseudoclymenia* sp.
318	132	*Protornoceras* sp.
378	133	*Protornoceras* sp.
288	134	*Protornoceras* sp.
343	135	tornoceratid sp. nov.
363	136	tornoceratid sp. nov.
388	137a,b	? *Pseudoclymenia* sp. nov.
378	138	? *Pseudoclymenia* sp. nov.
388	139	*Ps. sedgwicki* (Münster)
378	140	*Ps. sedgwicki* (Münster)
378	141	*Ps. sedgwicki* (Münster)
283	142	*Ps. sedgwicki* (Münster)
358	143	*Ps. sedgwicki* (Münster)
353	144	*Ps. sedgwicki* (Münster)
383	145	*Pseudoclymenia* sp.
283	146	*Ps. sedgwicki* (Münster)
378	147	*Ps. sedgwicki* (Münster)
343	148	*Ps. sedgwicki* (Münster)
-	149	*Ps. sedgwicki* (Münster)
-	150	*Ps. sedgwicki* (Münster)
378	151	*Ps. sedgwicki* (Münster)
333	152	*Ps. sedgwicki* (Münster)

388	153	_Ps._ _sedgwicki_ (Münster)
378	154	_Ps._ _sedgwicki_ (Münster)
348	155	_Ps._ _sedgwicki_ (Münster), cross-section
378	156	_Ps._ _sedgwicki_ (Münster), well preserved, showing the suture on the reverse.
	157	_Ps._ _sedgwicki_ (Münster), cross-section.
	158	_Ps._ _sedgwicki_ (Münster)
303	159	_Ps._ _sedgwicki_ (Münster)
323-78	160	_Ps._ _sedgwicki_ (Münster), well preserved, ornamented.
298	161	_Ps._ _sedgwicki_ (Münster)
378	162	_Ps._ _sedgwicki_ (Münster)
	163	_Ps._ _sedgwicki_ (Münster), shows suture.
323	164	_Pseudoclymenia_ sp.
323-78	165	_Pseudoclymenia_ sp.
-	166	_Ps._ _dillensis_ (Drevermann)
333	167	_Ps._ _dillensis_ (Drevermann)
328	168a,b	_Ps._ _dillensis_ (Drevermann)
348	169	_Ps._ _dillensis_ (Drevermann), cross-section.
313	170	_Prionoceras_ sp.
288	171	_Prionoceras_ sp.
348	172	_Prionoceras_ sp.
-	173	_Prionoceras_ sp.
388/5	174	_Prionoceras_ sp.
388/4	175	_Prionoceras_ sp.
378	176	_Prionoceras_ sp.
293	177	_Prionoceras_ sp.
323-78	178	_Prionoceras_ sp.
318	179	_Prionoceras_ sp.
283	180	_Prionoceras_ _frechi_ (Wedekind)
313	181	_Buchiola_ sp.
388	182	_Buchiola_ sp.
388/4	183	bivalve
318	184	
388	185	

Sample 378 yielded conodonts of _marginifera_ Zone age (see Chapter 6).

Sample		Bed	No.	Name
				Hövel
91			186	? *Sporadoceras*
106			187	goniatite indet.
81			188	*Plat*. (*Plat*.) *pompeckii* (Wedekind)
			189	
76			1900	*Sporadoceras* (*Sp*.) *muensteri* (von Buch)
86			1901	indet. goniatite
			1902	indet. goniatite
101			1903	indet. goniatite
1982			1904	indet.
			1905	*Platyclymenia* sp.
71			1906	*Platyclymenia* sp.
			1907	*Platyclymenia* sp.
61			1908	indet.
			1909	indet.
			1910	? *Clymenia spiratissima*, note whorl section
56			1911	*Prionoceras* sp.
			1912	indet.
			1913	indet.
			1914	
			1915	
292			1916	indet. clymeniid
				Sections B and C
186	B	5a	1917a-c	*Cl*. *laevigata* (Münster)
			1918	*Kosmo*. *subundulata* (Wedekind)
			1919	*Cymaclymenia*
			1920	*Cl*. *laevigata*
			1921	*Kosmo*. *subundulata* (Wedekind)
			1922	*Cl*. *laevigata* (Münster)
			1923	cf. *Cl*. *laevigata* (Münster)
			1924	
161		5b	1925	? *Kosmo*. sp. nov.
			1926	*Cyma*. *costellata* (Münster)
			1927	*Kosmo*. aff. *inaequistriata* (Münster)
			1928	*Kosmo*. aff. *inaequistriata* (Münster)
166		6a2	1929	*Prionoceras* sp.

			1930	*Cyma*. sp.
176		6a1	1931	*Cl*. *laevigata* (Münster)
191		6a	1932	*Kosmo*. sp.
			1933	*Cyma*. sp.
			1934	? *Progonioclymenia*
			1935	*Kosmo*. *inaequistriata* (Münster)
			1936	*Kosmo*. sp.
171		8a	1937	indet.
			1938	*Cyrtocl*. cf. *plicata* (Münster)
			1939	*Prionoceras* sp.
206	C	1.1	1940	Gen. Nov. *D* cf. *acuta* (Schmidt)
221		1.2	1941	*Cl*. *laevigata* (Münster)
526		3	1942	? *Gon*. (*Gon*.) sp.
			1943	*Cl*. *laevigata* (Münster)
			1944	indet.
			1945	indet.
			1946	*Cl*. *laevigata* (Münster)
			1947	*Cl*. *laevigata* (Münster)
331		6	1948	? *Progonioclymenia* (*Prog*.) *aegoceras* (Wedekind)
			1949	*Cyrto*. sp.
526		3	1950	*Cl*. *laevigata* (Münster)
			1951	*Cl*. *laevigata* (Münster)
			1952	*Posttornoceras* sp.
			1953	*Cl*. *laevigata* (Münster)
506		3	1954–1958	*Cl*. *laevigata* (Münster)
286		4/5	1959	*Cl*. *laevigata* (Münster)
			1960	*Cl*. *laevigata* (Münster)
			1961	*Cl*. *laevigata* (Münster)
271		4/5	1962	*Cl*. *laevigata* (Münster)
226		4/5	1963	*Cl*. *laevigata* (Münster)
266		4	1964	*Cl*. *laevigata* (Münster), shows body chamber constrictions
			1965	*Cl*. *laevigata* (Münster)
			1966	*Cl*. *laevigata* (Münster)
			1967	*Cl*. *laevigata* (Münster)

261	5	1968	Cl. laevigata (Münster)
246	5	1969	Cl. aff. spiratissima (Schindewolf)
		1970	Cyma. sp.
216	5	1971	Cl. laevigata (Münster)
521	6	1972	Cl. laevigata (Münster)
		1973	Cl. laevigata (Münster)
		1974	Kosmo. subundulata (Wedekind)
		1975	? Cl. spiratissima (Schindewolf)
211	6	1976	Cl. laevigata (Münster)
236	6a	1977	Cl. laevigata (Münster)
		1978	Cl. laevigata (Münster)
531	6a	1979	Cl. laevigata (Münster)
231	6c	1980	Cl. laevigata (Münster)
496	7	1981	Gon. (Gon.) cf. hoevelensis Wedekind
		1982	indet.
		1983	Gon. (Gon.) sp.
341	?7	1984	cf. Cymaclymenia
496	7	1985	Kosmo. subundulata (Wedekind)
326	?7	1986	Cyma. sp. (see 2054)
356	7	1987	Kosmo. cf. inaequistriata (Münster)
496	7	1988	Kosmo. inaequistriata (Münster)
		1989	Cyma. sp. b ?
396	7/8a	1990	Gon. (Gon.) hoevelensis Wedekind
376	8a.1	1991	Prionoceras varicosum (Schindewolf)
371	8a.1	1992	Cyma. sp. juv.
		1993	
371	8a.1	1994	Gon. (Gon.) subcarinata praematura Wedekind
516	8a.1	1995	Imitoceras sp.
		1996	Kosmo. aff. inaequistriata (Münster)
291	8a.3	1997	Kosmo. aff. inaequistriata (Münster) and Cyma. tricarinata Lange
441	8a.6	1998	Kosmo. sp.
		1999	Kosmo. sp.
		2000	Kosmo. subundulata (Wedekind)
		2001	Kosmo. subundulata (Wedekind)
		2002	Kosmo. subundulata (Wedekind)
346	8a.6	2003	Kosmo. aff. inaequistriata (Münster)
		2004	Kosmo. aff. inaequistriata (Münster)
361	8a.5	2005	Cyma. indet.

		2006	Kosmo. indet.
321	8a.4	2007	Cyma. indet.
431	8a.5	2008	Prionoceras sp.
311	8a.3	2009	Kosmo. inaequistriata (Münster)
476	8a.3	2010	Kosmo. inaequistriata (Münster)
		2011	Kosmo. inaequistriata (Münster)
		2012	Kosmo. inaequistriata (Münster), affixed to 2010
366	8a.1	2013	Kosmo. inaequistriata (Münster)
466	9.4	2014	Kosmo. effenbergensis, Korn and Price in preparation.
		2015	Kosmo. inaequistriata (Münster)
461	8a.7	2016	Kosmo. inaequistriata (Münster)
481	8a.7	2017	? Cyma. sp.
	.	2018	
296	8a.8	2019	Imitoceras sp.
306	9.1	2020	Kosmo. cf. inaequistriata (Münster)
466	9.7	2021	Kosmo. effenbergensis
		2022	Cyrtoclymenia sp.
		2023	Imitoceras globosum Schindewolf
381	9.3	2024	Kosmo. effenbergensis
		2025	Kosmo. effenbergensis
		2026	Kosmo. indet.
		2027	Kosmo. inaequistriata (Münster)
391	9.2	2028 2029 2030	Cymaclymenia aff. striata (Münster)
		2031	cyrtoconic nautiloid
351/386	8b/9	2032	Prog. aegoceras (two specimens)
		2033	Cl. laevigata (Münster)
		2034	Sell. torleyi (Wedekind)
		2035	Kosmo. inaequistriata (Münster)
		2036	Prog. (Prog.) aegoceras (Wedekind)
471	8	2037	Kosmo. sp.
451	8	2038	Kosmo. sp.
401	8	2039	Kosmo. effenbergensis
421	8	2040	nautiloid
486	9.1	2041 2042	Kosmo. inaequistriata (Münster)
291	8a.6	2043	Kosmo. inaequistriata (Münster)
521	6	2044	Sell. aff. plana (Münster)

		2045	Cyma. costellata (Münster)
		2046	indet.
		2047	indet.
		2048	indet.
		2049	cf. Cl. laevigata (Münster)
276	4-6	2050	indet.
216	5	2051	Cyma. sp., with strong ribs (with 1971)
496	7	2052	gastropod
		2053	indet.
		2061-8	(see Müssenberg)
		2069-80	(see Oberrödinghausen)
		2081	(see Ainkhausen)
332/7		2082	Sporadoceras sp.
342	6c	2083	Cl. laevigata (Münster)
337	7	2084	Cl. laevigata (Münster)
		2085	Imitoceras sp.
		2086	Sell. torleyi (Wedekind)
		2087	Cl. laevigata (Münster)
		2080	

For Hövel see also 2363-73

Müssenberg

172	2061	Wock. sphaeroides (Richter) and Pr. (Kenseyoceras) nucleus (Schmidt)
	2062	- ditto -
	2063	indet.
167	2064	Acutimitoceras substriatum (Münster)
	2065	Acutimitoceras sp.
	2066a-c	Acutimitoceras sp.
	2067	Acutimitoceras sp.
	2068	Acutimitoceras prorsum prorsum (Schmidt)
	2069-80	(see Oberrödinghausen)

Nehden

Hohlweg

	2193	<u>Archoceras</u>, very rare
	2194	posidoniid bivalves
	2195	posidoniid bivalves, brachiopods, pyritised goniatites and <u>Paratorleyoceras</u>.
	2196	crinoid
	2197	crinoid
	2198	brachiopods
	2199	orthocone
	2200	<u>Cheiloceras</u> sp.
	2201	nodule
	2202-10	(see Wäschholz)

Oberrödinghausen

140	2069	<u>Wock</u>. <u>sphaeroides</u> (Richter)
	2070	<u>Gon</u>. (Subgen. Nov. <u>B</u>) <u>wocklumensis</u> Lange
141	2071	<u>Kosmo.</u> sp.
	2072	<u>Kosmo</u>. sp.
	2073	<u>Kosmo</u>. <u>inaequistriata</u> (Münster)
	2074	<u>Prionoceras</u> sp.
142	2075	<u>Cyma</u>. sp. <u>a</u>
	2076	<u>Imitoceras</u> sp.
	2077	indet.
	2078	indet.
	2079	<u>Kosmo</u>. <u>similis</u> (Münster)
143	2080	<u>Kosmo</u>. <u>undulata</u> (Münster)

141 & 143 collected <u>in situ</u> = Ziegler's (1962), Sample 16, <u>subarmata</u> Zone.

	2081	(see Ainkhausen)
	2082-7	(see Hövel)

Oese

79/86	2088	<u>Posidonia</u>

87	2089-94	flattened *Platyclymenia* indet.
88	2095	bivalves
89	2096	squashed *Platyclymenia*
77	2097	*Imitoceras* cf. *quadripartitum* (Münster)
73	2098	? *Kosmoclymenia*
74	2099	*Orthoceras*
72	2100	*Imitoceras* sp.
	2101	*Imitoceras* sp.
	2102	*Imitoceras* sp.
	2103	*Cyma*. aff. *barbarae* (Loewinson-Lessing)
	2104a,b	*Cyma*. aff. *barbarae* (Loewinson-Lessing)
	2105	indet.
69	2106	*Imitoceras* sp.
	2107	*Imitoceras* sp.
	2108	crinoid ossicle
67	2109	*Imitoceras* sp.
66	2110	nautiloid
65	2111	*Para*. *paradoxa* (Wedekind)
	2112	*Para*. *paradoxa* (Wedekind)
61	2113	*Gon*. (*Kall*.) *subarmata* (Münster)
62	2114	*Imitoceras* sp.
63	2115	cf. *Gon*. (*Kall*.)
	2116a,b	*Wock*. *sphaeroides* (Richter)

Reigern

Beds		
2	2117	*Imitoceras* sp.
9	2118-23	*Imitoceras* sp.
	2124	*Kosmo*. sp.
	2125	*Cyma*. sp.
	2126	*Kosmo*. sp.
	2127	*Kosmo*. sp.
	2128	*Kosmo*. sp.
10	2129	*Imitoceras* sp.
	2130	*Kosmo*. sp.
13	2131	*Kosmo*. sp.
	2132	*Kosmo*. *wocklumeri* (Wedekind)
14	2133	*Kosmo*. sp.
15	2134	*Cyma*. sp.
21	2135	*Cyma*. sp.

	2136	juvenile specimens
	2137	*Kosmo*. sp.
14	2138	*Kosmo*. sp.
21	2139	*Cyrto*. sp.
24	2140	indet.
	2141	*Cyma*. sp.
27	2142	*Imitoceras* sp.
	2143	*Imitoceras* sp.
	2144	*Cyma*. *sp*.
	2145	*Pr*. (*Kenseyoceras*) sp.
27	2146	*Pr*. (*Kenseyoceras*) sp.
loose	2147	orthoceratid
	2148	*Gon*. (*Kall*.) cf. *subarmata* (Münster)
	2149	*Kosmo*. cf. *schindewolfi* (Korn and Price in preparation)
	2150	*Imitoceras* indet.
	2151	*Imitoceras* ?*globosum* Schindewolf
33	2152	*Gon*. (*Kall*.) sp. nov. aff. *subarmata* (Münster)
	2153-64	*Kosmo*. *undulata* (Münster)
	2165-70	*Kosmo*. *similis* (Münster)
	2171-2	?Gen. Nov. (undescribed)
	2173	*Cyma*. sp., strong ribs
	2174-7	*Cyma*. aff. *barbarae* (Loewinson-Lessing)
	2178-81	*Cyrto*. aff. *plicata* (Münster)
	2182-3	*Sporadoceras* sp.
33	2184	*Imitoceras* *quadripartitum* (Münster)
	2185-7	*Imitoceras* cf. *globosum* Schindewolf
	2188	*Sporadoceras* sp.
	2189	*Imitoceras* *quadripartitum* (Münster)
	2190	*Imitoceras* *lineare* (Münster)
	2191	*Imitoceras* *quadripartitum* (Münster)
	2192	*Imitoceras* *quadripartitum* (Münster)

2193-2201 (see Nehden)

2314	*Kosmo*. *undulata* (Münster)
2315	*Sporadoceras* sp.

Wäschholz

	2202-5	Gen. Nov. sp. nov.
	2206	Gen. Nov. aff. sp. nov.
	2207	cf Protoxyclymenia
	2208	cf Aktuboclymenia ancestralis (Korn and Price, in preparation)
	2209	phacopid
	2210	Plat. (Plat.) richteri Wedekind

In situ Beil Trench E

21b1	2211	Pernoceras cf. planidorsatum (Münster)
15a6	2212	Torleyoceras curvispina (Sandberger and Sandberger)
15a2	2213	indet.
15c1	2214	indet.
14d-	2215	indet.
14c1	2216	Cheil. cf. pompeckji Wedekind
14b2	2217	Torl. curvispina (Sandberger and Sandberger)
14b3	2218	Torl. curvispina (Sandberger and Sandberger)
14b7	2219	Paratorleyoceras globosum (Münster)
14b1	2220	Gen. Nov. aff. Dimeroceras sp. nov.
11b top 2	2221	Gen. Nov. aff. Dimeroceras sp. nov.
14a7	2222	Paratornoceras sp. nov. cf. lentiforme sensu Petersen
14a6	2223	?Gen. Nov. aff. Dimeroceras sp.
11g1	2224	Spor. aff. biferum (Phillips)
11b top 1	2225	Sp. sp.
11a2	2226	Sp. aff. biferum (Phillips)
	2227	Sp. biferum (Phillips)
10f1	2228	Sp. biferum (Phillips)
10f2	2229	Sp. biferum (Phillips)
10c1	2230	Sp. biferum (Phillips)
10c2 a-b	2231	Sp. biferum (Phillips)
10c3	2232	Sp. biferum (Phillips)
10b3	2233	Sp. biferum (Phillips)

	10b2	2234	Sp. descendens Schmidt
	10b1	2235	Sporadoceras aperture
	10a1-b	2236	Sp. biferum (Phillips)
	9g5	2237	Sp. biferum (Phillips)
	9g4	2238	Sp. (Sp.) biferum (Phillips)
	9f1	2239	Sp. biferum (Phillips)
	9f2	2240	Sp. biferum (Phillips)

Beil, above Trench E

	9g3	2241	clymeniid ? (note apparent dorsal siphuncle)
	10f	2242	?Cheiloceras
	14b10	2243	cf. Paradimeroceras
C1		2244	Pseudoclymenia dillensis (Drevermann)
79/45		2245	?Cheiloceras
44		2246	cheiloceratid
67a-b	45	2247	Sporadoceras sp.
62	45	2248	Sporadoceras posthumum Wedekind
66	45	2249	part of 2247
68	45	2250	Sporadoceras muensteri (Buch)
61	42	2251	Sporadoceras inflexum Wedekind
63	42	2252	cf. Gen. Nov. D
64	40	2253	cf. Gen. Nov. D or Cyrtoclymenia
262	32/3	2254	Gen. Nov. D
262	32/3	2255	Sporadoceras muensteri (Buch)
262	32/3	2256	?Protornoceras
70	30-50	2257	Sporadoceras inflexum Wedekind
75	10-50	2258	Sporadoceras posthumum Wedekind
74	10-50	2259a-c	Sporadoceras muensteri (Buch)
	14a4	2260	Cheiloceras cf. circumflexum (Sandberger and Sandberger)
262	32/3	2261	Sporadoceras muensteri (Buch)
277	loose	2262	Sporadoceras muensteri (Buch)
277	loose	2263	cf. Gen. Nov. D stuckenbergi (Tokarenko)
262	32/3	2264	Sporadoceras muensteri (Buch)
262	32/3	2265	Sporadoceras cf. muensteri (Buch)
267	1-10	2266	Sporadoceras sp.
267	1-10	2267	Prionoceras frechi (Wedekind)
267	1-10	2268	Prionoceras sp.
282	32/3	2269	Sporadoceras sp.

282	32/3	2270	Sporadoceras sp.
		2271	Sporadoceras muensteri (Buch)
		2272	Sporadoceras sp.
		2273	Sporadoceras muensteri (Buch)
		2274	Prionoceras frechi (Wedekind)
44	2	2275	Sporadoceras posthumum Wedekind
47	6	2276a,b	Plat. (Plat.) quenstedti Wedekind
48	6	2277	Plat. (Plat.) quenstedti Wedekind
57	9	2278	Sporadoceras posthumum Wedekind
45	2	2279	Prionoceras sp.
	1-10	2280	Plat. (Plat.) quenstedti Wedekind
	1-10	2281	Sporadoceras sp.
	1-10	2282	Sporadoceras sp.
	1-10	2283	Plat. (Plat.) cf. senilis Lange
	1-10	2284	cf. Plat. (Plat.) quenstedti Wedekind
	1-10	2285	Plat. (Plat.) richteri Wedekind
	1-10	2286	Plat. (Plat.) quenstedti Wedekind
	1-10	2287	Plat. (Plat.) indet.
353	annulata Zone	2288	Plat. (Plat.) sp.
		2289	Plat. (Plat.) richteri Wedekind, borings in body chamber shell.
		2290	Plat. (Plat.) sp.
		2291	?Platyclymenia
		2292	Plat. (Plat.) sp.
		2293	Plat. (Plat.) intracostata (Frech)
		2294	Plat. (Plat.) ruedemanni Wedekind
		2295	Plat. (Plat.) richteri Wedekind
		2296	Plat. (Plat.) richteri Wedekind
		2297	Plat. (Plat.) ruedemanni Wedekind
272	25	2298	Sporadoceras sp. and Gen. Nov. D stuckenbergi (Tokarenko)
		2299	Plat. (Plat.) sp.
		2300	Sporadoceras sp.
		2301	Sporadoceras sp.
—		2302	Paratornoceras lentiforme (Sandberger)
42		2303	?Protornoceras sp.
	A1-10	2304	Plat. (Plat.) ruedemanni Wedekind
	1b	2305	Prionoceras divisum (Münster)
	1b	2306	Prionoceras divisum (Münster)

		2307	
	1b	2308	*Prionoceras frechi* (Wedekind)
		2309	
	1b	2310	*Plat*. (*Trig*.) *spinosa* (Münster)
		2311	
352	*Clymenia* Stufe	2312	*Kosmo*. cf. *colubrina* (Lange)
		2313	*Kosmo*. (Group II) sp.
		2314-5	(see Reigern)

Hövel

1982		2363	indet.
		2364	orthocone
		2365	*Plat*. cf. *valida sensu* Drevermann
		2366	*Platyclymenia* sp.
		2367	*Platyclymenia* sp.
		2368	*Posttornoceras* sp. (note spiral ornament)
		2369	indet.
		2370	*Platyclymenia* sp.
		2371	?*Plat*. (*Trigonoclymenia*) sp.
		2372	*Plat*. sp.

Appendix 2

Samples	Locality	Reference
79/2,23-29	Ainkhausen	See Textfig. 7.8
79/42,44,45	Beil	7.9
79/61-86	Oese	7.19
79/102	Beil	7.9
112,120,123	Effenberg	7.14
117,122,124-30	Bilsteinhöhle	7.5d
140-3	Oberrödinghausen	
167,172	Müssenberg	
262,272,277,282	Beil	7.9
288-388 (xx3 & xx8 only)	Geuser	
352,353,367	Beil	7.9

Hövel

Hövel Sections A and D Textfig. 7.16a

332
056
061
071
076
081
086
091
101
121

Hövel Section B Textfig. 7.16b

	Beds
141	
146	8b
151	-
156	4
161	5b
166	6
171	8b

Sample	Beds
176	6
181	5b
186	5a
191	6

Hövel Section C Textfig. 7.16b

Sample	Beds	Sample	Beds
201	1	342	6c
206	1	347	3
211	6	352	See Beil
216	5	353	See Beil
221	1	361	8a.5
226	4/5	366	8a.1
231	6c	367	See Beil
236	6a	371	8a.1
246	5	401	8-10
261	5	421	8-10
262	See Beil	431	8a.4
271	4/5	446	8a.8
272,277,281	See Beil	451	8-10
306	8	456	8a.1
311	8a.3	461	8a.6
316	8a.2	466	9.4
321	8a.4	471	8-10
326	? 7	506	3
331	6	516	8a.1
332	Section A, above	521	6
337	5	526	3
341	? 7	531	6a

Chapter 8

A short biography of Count Münster, including a list of his publications dealing with Famennian ammonoids

This study revolves around the collections of Count Münster (frontispiece) and it would seem useful to give some biographical details and to list some of his publications. He was born on 17 February 1776 at Langelage in Westphalia (Weiss 1937). His working life was spent in the Prussian Civil Service, including a long period in Bayreuth, which resulted in his interest in Famennian ammonoids, collected in nearby Oberfranken.

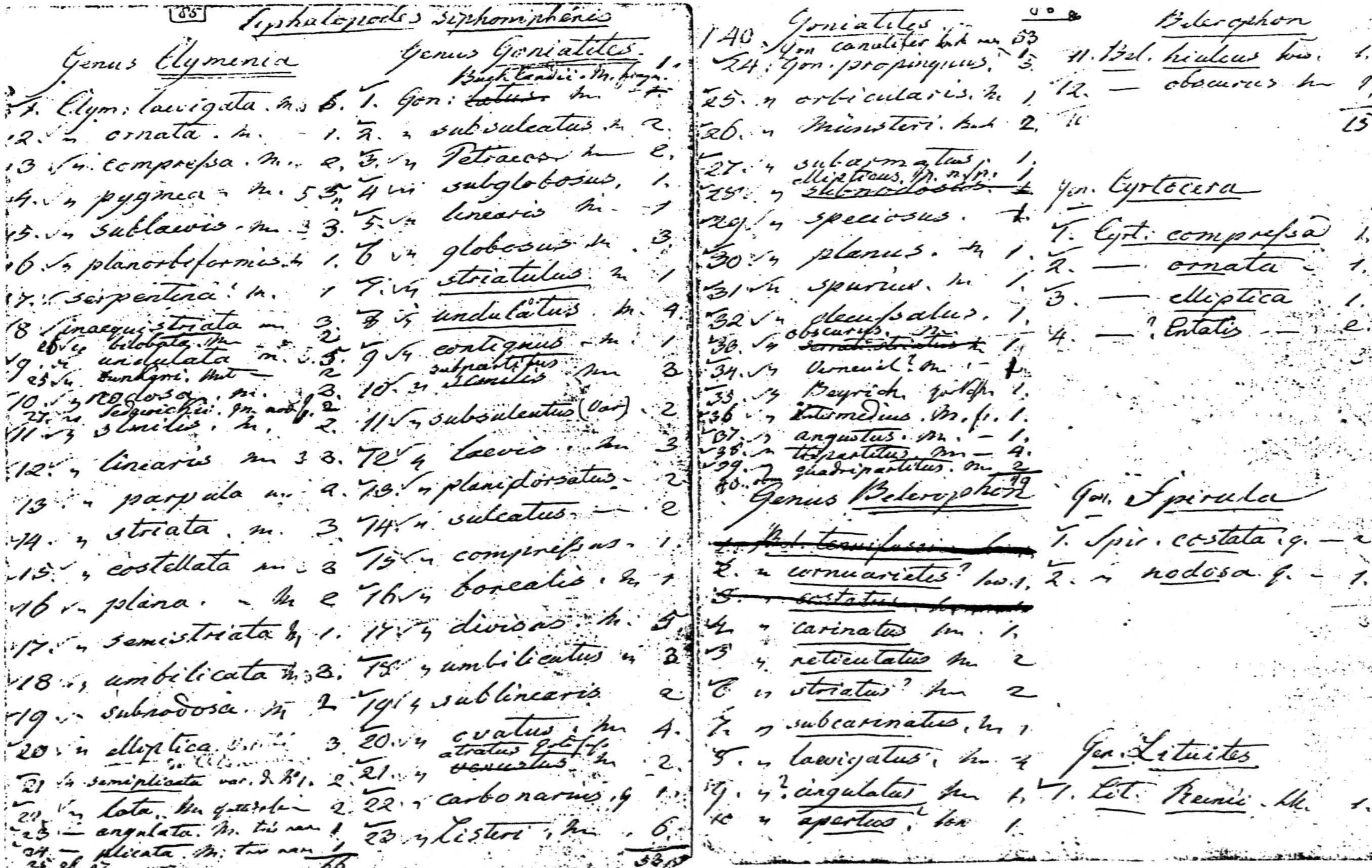
Münster travelled throughout Europe and developed a wide interest in palaeontology. He was responsible for early discoveries from the Lithographic Limestones at Solenhofen, and for recognising the Trassic age of the St. Cassian Beds of the South Tirol. The majority of his work, however, was done in Franconia. From the Obermain district alone he described nearly 900 species. He cooperated with Goldfüss in producing the Petrefacta Germaniae (1826-44) a work which ranks with Sowerby's Mineral Conchology and d'Orbigny's Paléontologie Française, which were being published around the same time.

In 1840 he received a pension and spent the last four years of his life writing and editing his own journal Beitrage zur Petrafaktenkunde, of which six volumes appeared before his death. A significant part of these issues deals with faunas of Silurian to Carboniferous age extracted from limestones brought to St. George's Prison near Hof for crushing and burning. These came from Schübelhammer, Elbersreuth, Horwagen and Gattendorf.

Münster's contributions to the study of Famennian ammonoids began in 1831 in two lectures read to the Geological Society of France, describing the distribution of ammonoids (1831a) and nautiloids (1831b) in Germany. Full details of the Famennian ammonoids were given in Die Planuliten und Goniatiten im Uebergangskalk des Fichtelgebirges (1832) in which 34 new species were introduced. In 1834 (1834b) this work was translated into French, with a supplemental description of two new species. The name Clymenia was also introduced at this time, although the intention to do this had been announced sometime earlier (1834a). All of Münster's subsequent publications on Famennian ammonoids are to be found in the Beitrage zur Petrefaktenkunde. These comprise many relatively short articles, which, for brevity, are usually referred to by the volume number in which they appear, rather than individually. They are all listed below.

During his life Münster amassed a vast collection of fossils. At his death this became dispersed, going to Erlangen and Bayreuth, but the bulk of it was purchased for 60 000 Marks by the State of Bavaria, and removed to Munich. Unfortunately a part of this collection (although not the primary types) was destroyed at the close of the last war. Specimens from Erlangen have been used in this study, and the Famennian ammonoids from the collection at Bayreuth have now been transferred to Munich. Material was sent by Münster to von Buch (von Buch 1832) and some of this is now in the Museum für Naturkunde, Berlin.

Münster formed a duplicate collection at a time when he hoped to sell his main collection to the King of Bavaria. This sale fell through. Sedgwick and Murchison visited Münster in the summer of 1839 and they persuaded him to sell this duplicate collection for the sum of £500 (Clark and Hughes 1890). Over 22 000 specimens were acquired, and they formed the basis of the Woodwardian/Sedgwick Museum in the University of Cambridge. A catalogue in the Count's own handwriting was provided with the collection, and the section dealing with Famennian ammonoids is reproduced in Textfig. 8.1. Examples of handwritten labels accompanying each fossil are illustrated in Textfig. 8.2. This



[85] Cephalopodes siphonophères

Genus Clymenia
1. Clym. laevigata. M. 6.
2. ornata. M. 1.
3. compressa. M. 2.
4. pygmaea M. 5
5. sublaevis M. 3.
6. planorbiformis M. 1.
7. serpentina M. 1
8. inaequistriata M. 3
bilobata M.
9. undulata M. 5.
25. Dunkeri M. 2
10. nodosa M. 3.
27. Sedgwickii M. 2
11. similis M. 2.
12. linearis M. 3.
13. parvula M. 9.
14. striata M. 3
15. costellata M. 3
16. plana M. 2
17. semistriata M. 1.
18. umbilicata M. 3.
19. subnodosa M. 2
20. elliptica 3.
21. semiplicata var. 2.
22. lata M. 2.
23. angulata M. 1
24. plicata M. 1
25. 26. 27.
66

Genus Goniatites
1. Gon. ~~latus~~ M. 1
2. subsulcatus M. 2
3. Petraeus M. 2.
4. subglobosus 1.
5. linearis M. 1
6. globosus M. 3.
7. striatulus M. 1
8. undulatus M. 4.
9. contiguus M. 1
10. subpartitus M. 3
11. subsulcatus (Var.) 2
12. laevis M. 3
13. planidorsatus 2
14. sulcatus 2
15. compressus 1.
16. borealis M. 1
17. divisus M. 5.
18. umbilicatus M. 3
19. sublinearis 2
20. ovatus M. 4.
21. atratus 2.
22. carbonarius 1.
23. Listeri M. 6.
53

140 Goniatites 53
24. Gon. propinquus. 5.
25. orbicularis M. 1
26. Münsteri 2.
27. subarmatus 1.
28. ellipticus ~~subnodosus~~ 1
29. speciosus 1
30. planus M. 1
31. spurius M. 1.
32. obscurus 1.
33. 1
34. Verneuili? M. 1
35. Beyrichi 1.
36. intermedius M. 1.
37. angustus M. 1.
38. tripartitus M. 4.
39. quadripartitus M. 2
49

Genus Bellerophon
1. ~~Bel. tenuifascia~~
2. cornuarietes? 1.
3. ~~costatus~~
4. carinatus M. 1.
5. reticulatus M. 2
6. striatus? M. 2
7. subcarinatus M. 1
8. laevigatus M. 4
9. ?cingulatus M. 1.
10. apertus M. 1.

Bellerophon
11. Bel. hiulcus 1.
12. — obscurus 9.
15

Gen. Cyrtocera
1. Cyrt. compressa 1.
2. — ornata 1.
3. — elliptica 1.
4. — ? Entalis 2.

Gen. Spirula
1. Spir. costata 2
2. nodosa 1.

Gen. Lituites
1. Lit. Reinii M. 1.

Textfig. 8.1 Pages listing ammonoids from Münster's handwritten catalogue accompanying his collection in the Sedgwick Museum, Cambridge.

collection of Famennian ammonoids had lain largely unstudied and uncatalogued to the present day, and has proved useful in providing neotypes for species whose primary material has been lost.

Some specimens appear to have found their way from Cambridge to the British Museum (Natural History), where they can be identified by their distinctive labels, although no record of their provenance exists in the earliest catalogue which lists them. J. F. Lee's Collection, transferred to the British Museum (NH) from the Geological Survey in 1911, contains some Famennian ammonoids which were given to him by Münster.

Munster's publications dealing with Famennian ammonoids

1832 Uber die Planuliten und Goniatiten im Uebergangs-kalk des Fichtelgebirge. 38pp., 6pls., Bayreuth.

1833 Verzeichnis der Versteinerungen welche in der Kreis-Naturalien-Sammlung zu Bayreuth vorhanden sind. Bayreuth. (Pages 108-114 list the ammonoids occurring in the Count's collection, briefly stating how many specimens of each species there were. This catalogue has proved useful in determining the size of type series, although there are some inconsistencies).

1834a Mittheilung an Professor Brown. Neues Jahrbuch für Mineralogie, Geologie und Petrefaktenkunde, 42-43. (This letter, dated 1 December 1833, notifies Münster's intention to replace the name Planulites by Clymenia.)

1834b Mémoire sur les Clymènes et les Goniatites du Calcaire de transition du Fichtelgebirge. Ann. des Sciences naturelles 2ieme Série, Zool. 2, 65-99, pls. 1-6. (A translation of Münster 1832, with two species newly described.)

1839 Nachtrag zu den Clymenien des Fichtelgebirge, Beiträge zur Petrefaktenkunde 1, 6-16, 122, pls. II, XVI. (17 new species introduced.)

1839 Nachtrag zu den Goniatiten des Fichtelgebirge, B.z.P. 1, 17-31, pls. III, XVII, XVIII.

1839 Seltene Arten Clymenia Cyrtoceras und Orthocera aus dem Uebergangskalk, B.z.P. 1, 31-40.

1840 Die Versteinerungen des Uebergangskalkes mit Clymenien and Orthoceratiten von Oberfranken, B.z.P. 3, 33-121. (Part H Cephalopoda deals with clymeniids (91-4), and goniatites (105-111), which are illustrated in plate XVI. 5 species of clymeniid and 5 goniatites introduced.)

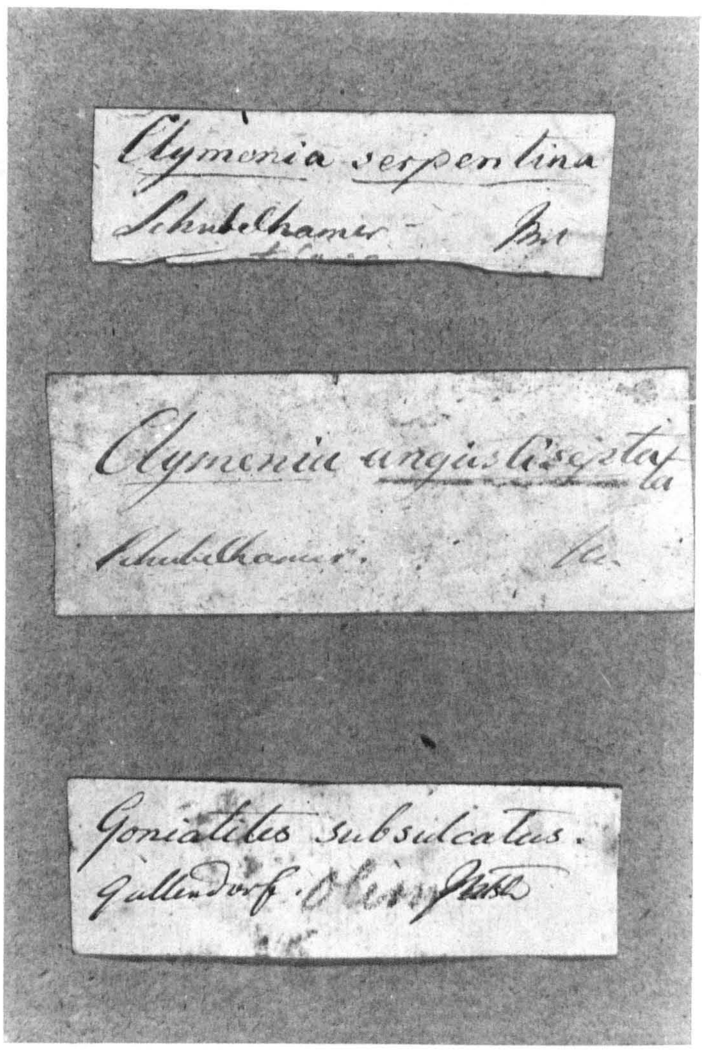
1842 Nachtrag zu den Versteinerungen des Uebergangskalkes mit Clymenien von Oberfranken, B.z.P. 5, 112-128. (Part V (122-128) deals with Cephalopods, illustrated in pls. XI and XII. Five clymeniid species introduced).

1843 Ueber die Clymenien und Goniatiten im Uebergangskalk des Fichtelgebirges, B.z.P. 1 (2nd Edition), 1-30, pls. Ia-VIa. (Münster 1832 reset, with some nomenclatural revision, and more heavily engraved plates with minor modifications.)

1843 Nachtrag zu den Clymenien des Fichtelgebirges, B.z.P. 1, (2nd Edition), 35-43, 127, pls. II, XV, XVI. (See above.)

1843 Nachtrag zu den Goniatiten des Fichtelgebirges, B.z.P. 1, (2nd Edition), 43-55, pls. III, XVII, XVIII. (See above.)

1843 Seltene Arten Clymenia, Cyrtocera und Orthocera aus dem Uebergangskalk, B.z.P. 1, (2nd Edition), 55-60. (See above.)



Textfig. 8.2 Labels written by Münster, accompanying type specimens in the Münster Collection, BSP.

Illustrations taken from the 19th Century Literature

Erklärung der Figuren.

Tab. I. Planuliten mit schwach gebogenen Loben.

Fig. 1. a bis f. Planulites laevigatus. n. von Schübelhammer.
fig. 2. a — d. Plan. pygmeus. n. von der Geigen bei Hof.
fig. 3. a — c. Plan. angustiseptatus n. von Schübelhammer.
fig. 4. a — c. Plan. compressus. n. von Schübelhammer.
fig. 5. a. b. Plan. inflatus. n. von Schübelhammer.

Tab. II. Planuliten mit spitzen Loben.

Fig. 1. a — c. Plan. planorbiformis. n. von Gattendorf bei Hof.
fig. 2. a — c. Plan. undulatus. n. von Schübelhammer.
fig. 3. a. b. Plan. laevis. n. von Schübelhammer.
fig. 4. a — c. Plan. inaequistriatus. n. von Schübelhammer.
fig. 5. a — b. Plan. linearis n. von Schübelhammer.
fig. 6. a — c. Der Steinkern von Plan. undulatus, laevis und linearis.
fig. 7. a — c. Plan. parvulus. n. von Elbersreuth.

Tab. III. Planuliten und Goniatiten.

Fig. 1. a — c. Plan. serpentinus. n. von Schübelhammer.
fig. 2. a — c. Plan. striatus, a) costellatus. n. desgleichen.
fig. 3. a — c. Plan. b) striatus. n. Schübelhammer.
fig. 4. Plan. c) semistriatus. n. ebendaher.
fig. 5. Plan. d) planus. n. desgleichen.
fig. 6. a — c. Goniatites hybridus. n. von Hartigwagen.
fig. 7. a — c. Gon. sulcatus. n. von Schübelhammer.
fig. 8. a — c. Gon. contiguus. n. ebendaher.

Tab. IV. Goniatiten mit einfachen, spitzen Loben.

Fig. 1. a — d. Goniatites ovatus. n. von Gattendorf.
fig. 2. a — c. Gon. sublaevis. n. von Gattendorf.

fig. 3. a bis d. Gon. undulosus. n. von Gattendorf.
fig. 4. a — c. Gon. globosus. n. von Gattendorf.
fig. 5. a — c. Gon. sublinearis. n. von Gattendorf.
fig. 6. a. — e. Gon. divisus. n. von. der Geigen und von Gattendorf.

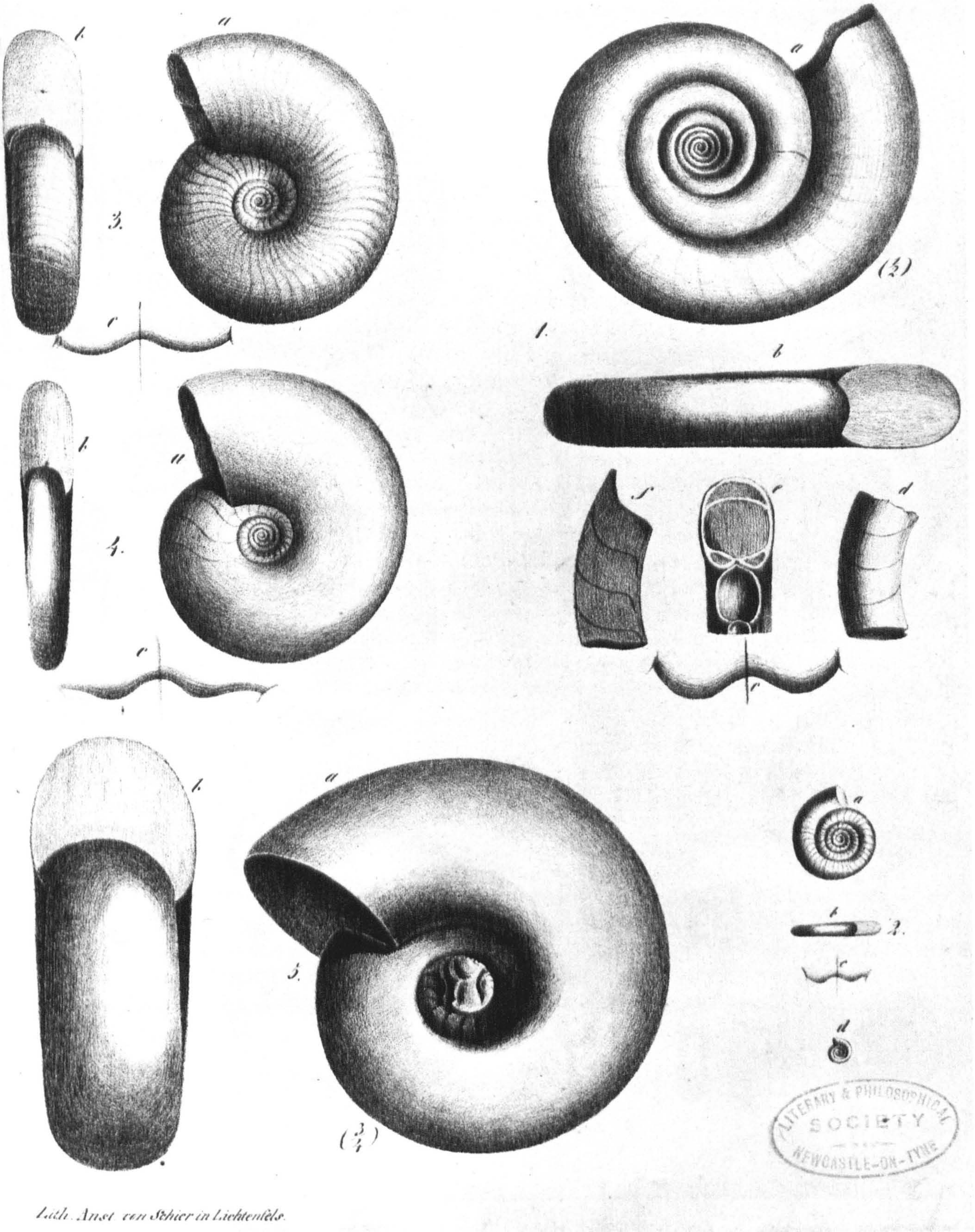
Tab. V. Goniatiten mit spitzen Loben.

Fig. 1. a — d. Gon. linearis. n. von der Geigen und von Schübelhammer.
fig. 2. a — d. Gon. subsulcatus. n. von Gattendorf und Schübelhammer.
fig. 3. a — c. Gon. Münsteri. Buch. von Schübelhammer.
fig. 4. a — d. Gon orbicularis. n. von Schübelhammer.

Tab. VI. Goniatiten mit spitzen Loben.

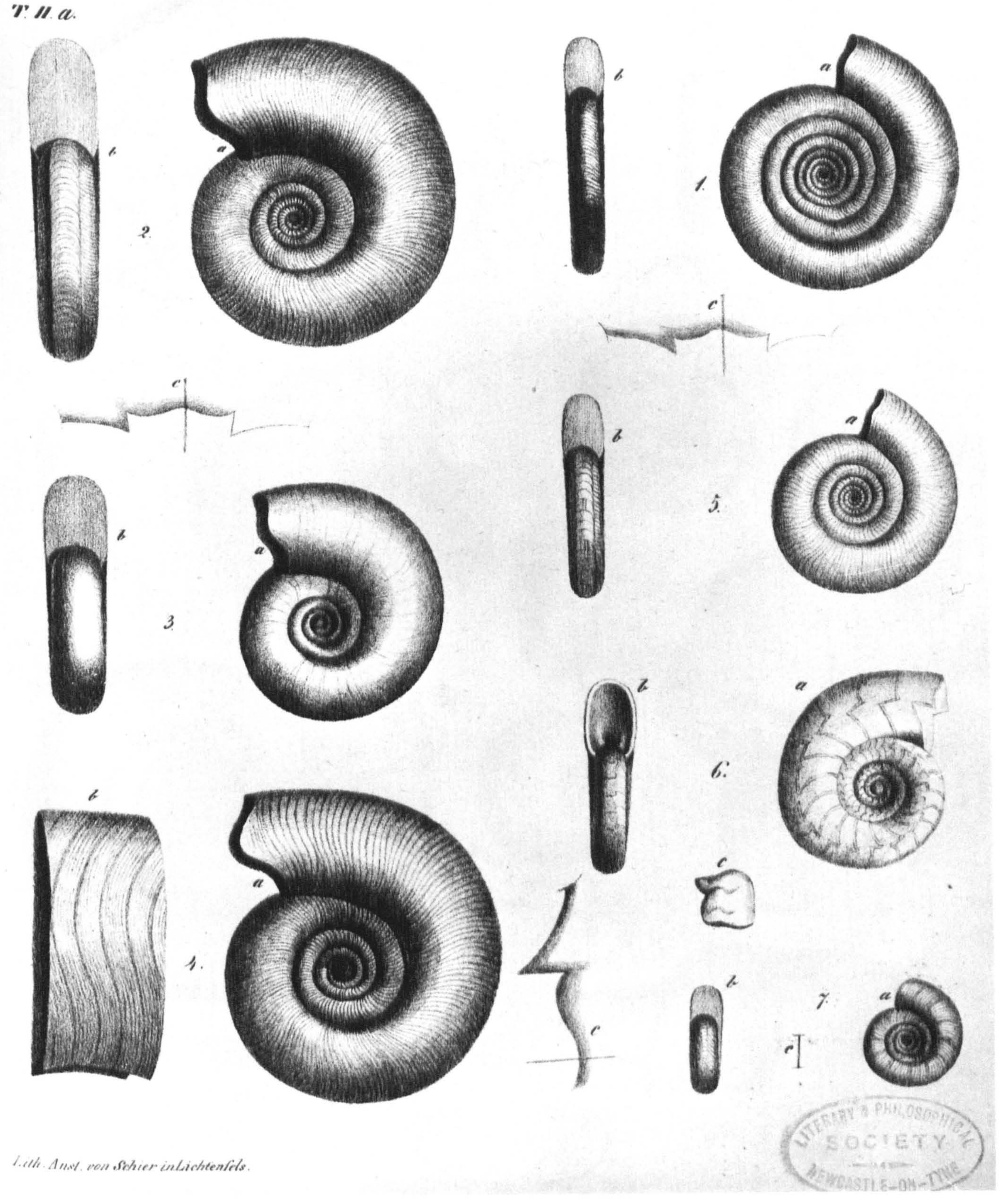
Fig. 1. a — c. Gon. speciosus. n. von Elbersreuth und Schübelhammer um die die Hälfte verkleinert.
fig. 2. a — c. Gon. subarmatus. n. von Schübelhammer um die Hälfte verkleinert.
fig. 3. Gon. maximus. n. von Schübelhammer um die Hälfte verkleinert.
fig. 4. a — c. Gon. planus. n. von Schübelhammer.
fig. 5. a. b. Gon. binodosus. n. ebendaher.
fig. 6. Gon. annulatus. n. von Regnitzlosau.
fig. 7. Gon. subnodosus. n. von Elbersreuth.

Münster 1832 (1843 edn.)



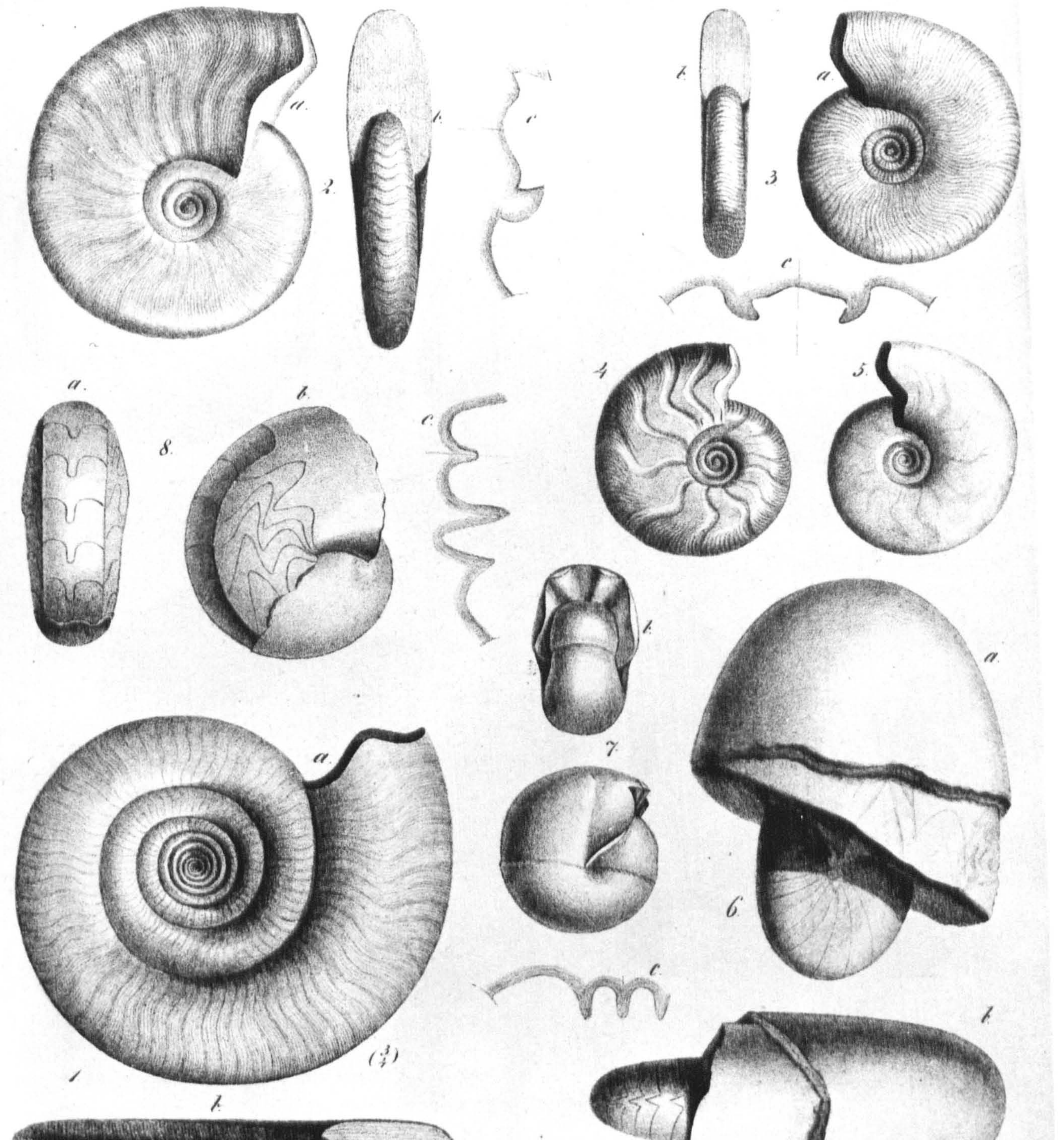
Lith. Anst. von Schier in Lichtenfels.

Münster 1832 (1843 edn.)



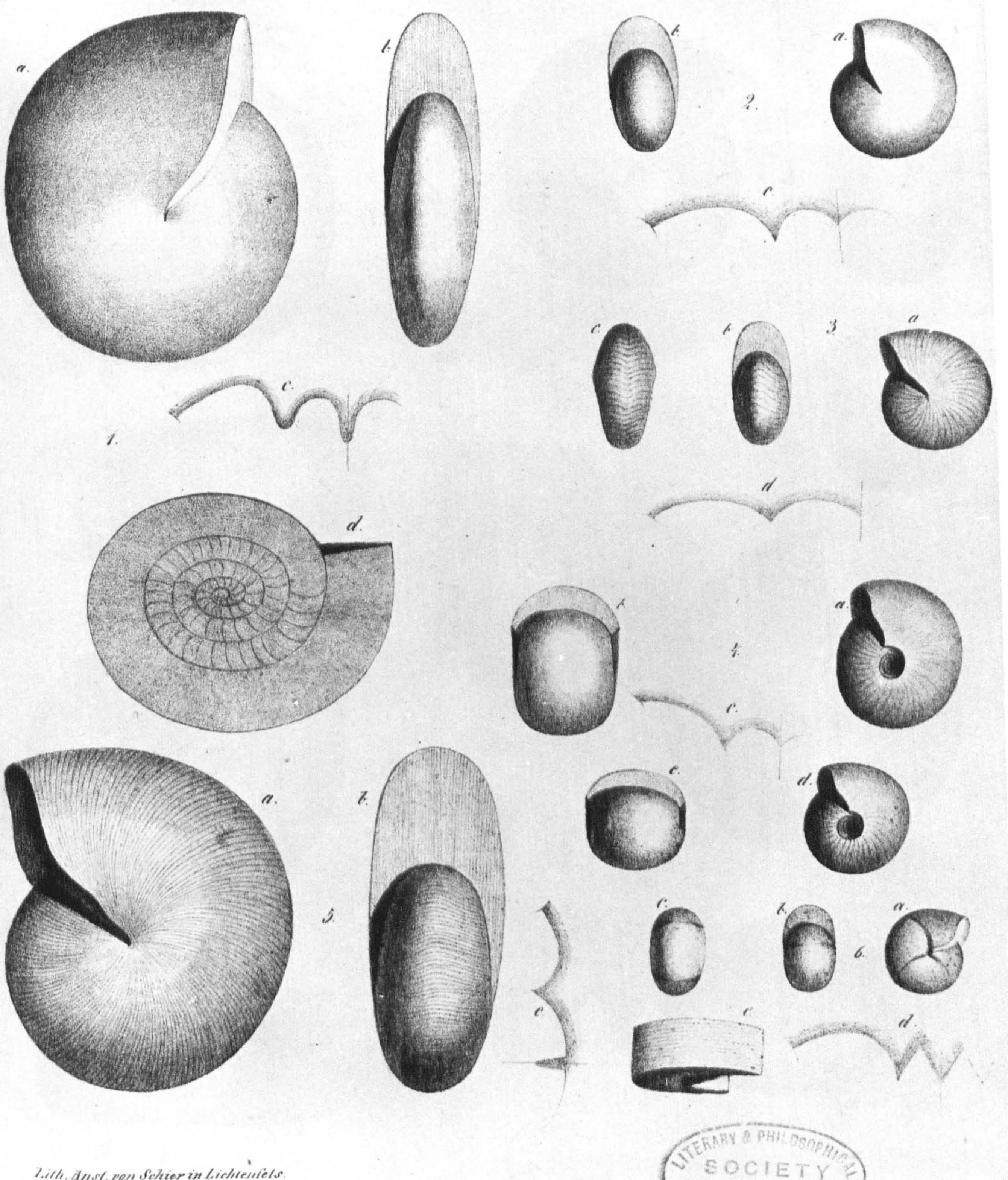
Münster 1832 (1843 edn.)

T. III. a.



Lith. Anst. von Schier in Lichtenfels

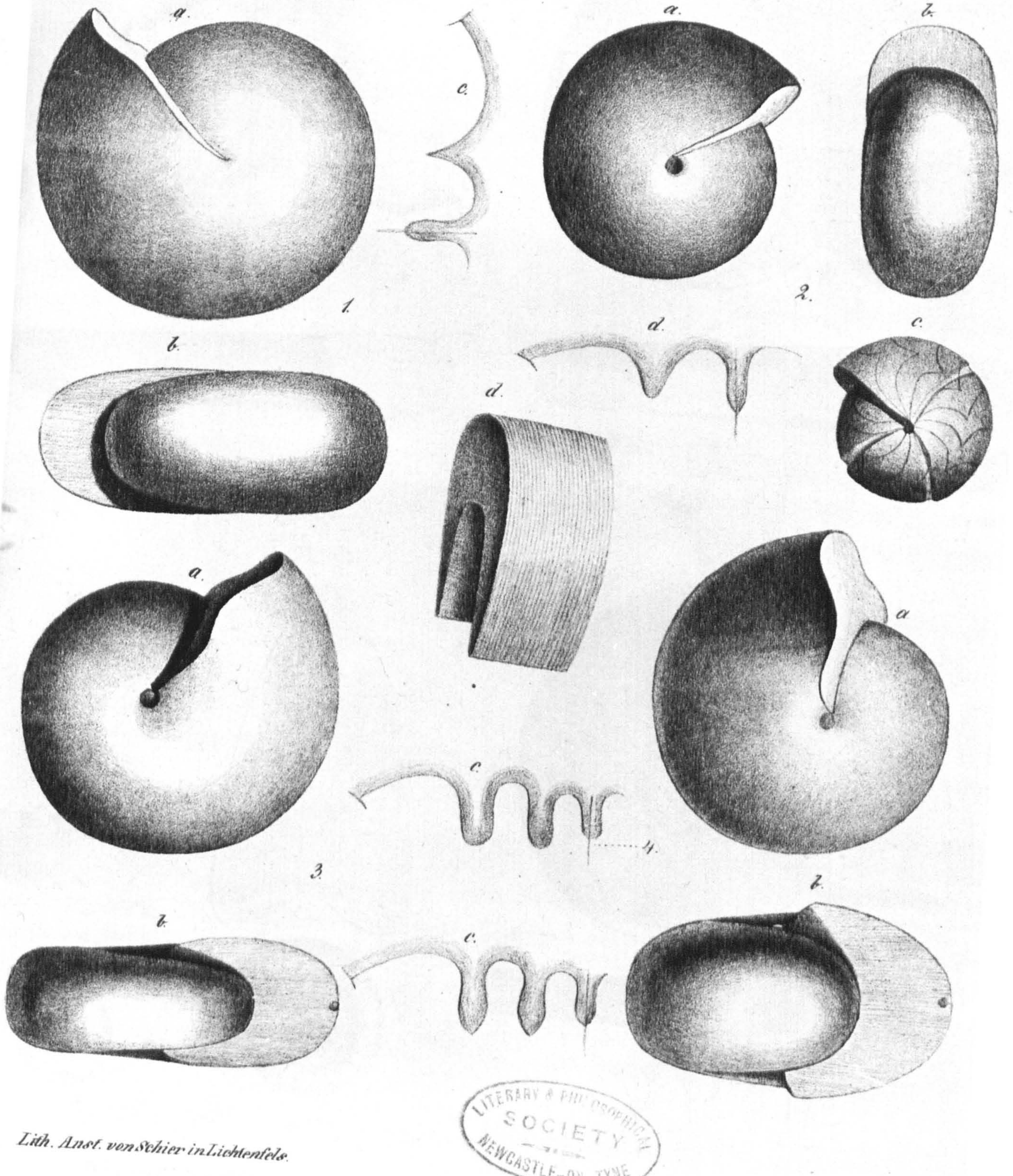
Münster 1832 (1843 edn.)



Lith. Anst. von Schier in Lichtenfels.

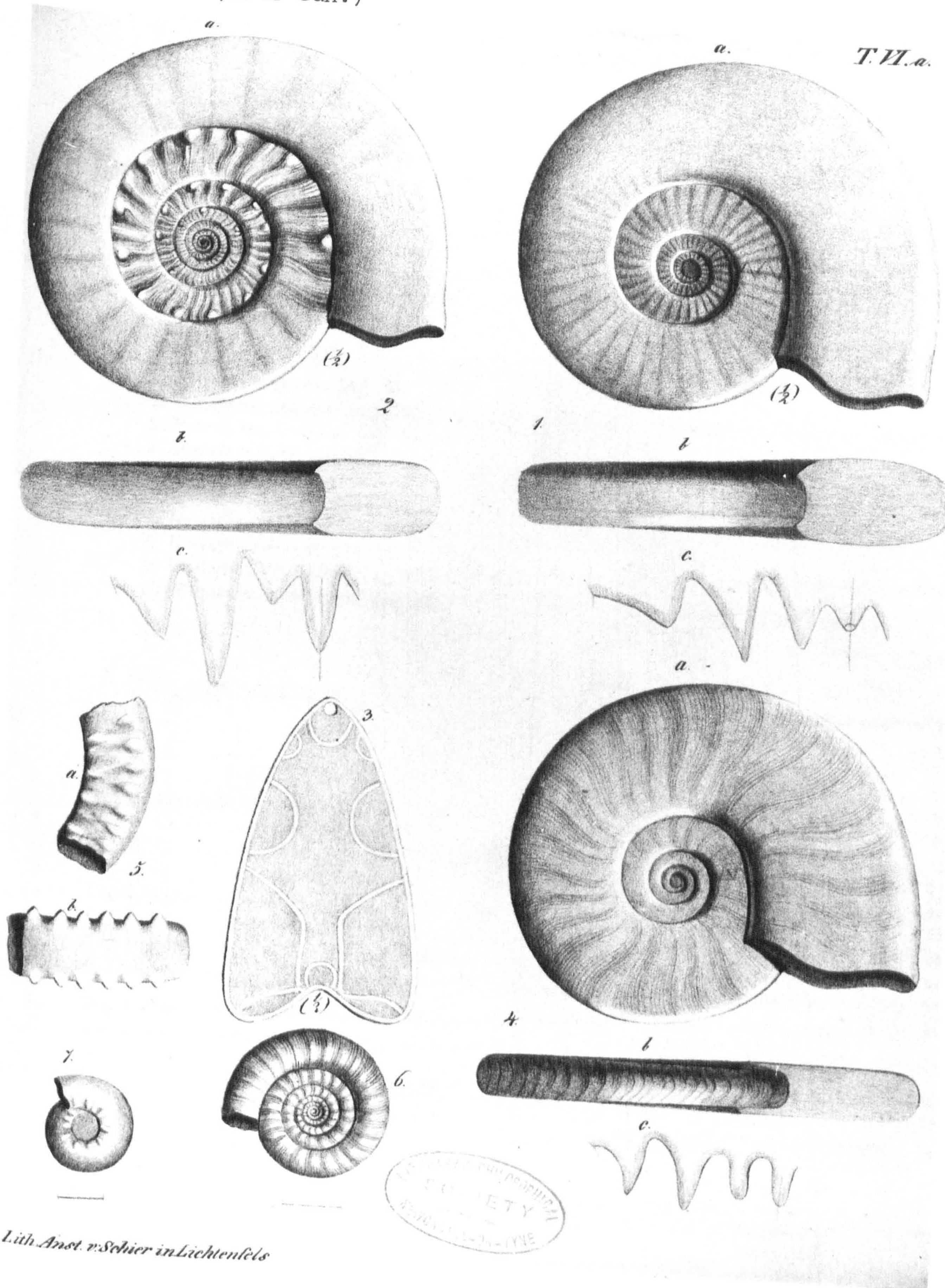
Münster 1832 (1843 edn.)

T.V.a.



Lith. Anst. von Schier in Lichtenfels.

Münster 1832 (1843 edn.)



Lith. Anst. v. Schier in Lichtenfels

Münster 1839

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Tafel II.

. 1. Cyrtocera Aigoceros. pag. 33 u. 34.
. 2. a — c. Cyrtocera tentaculata. p. 24.
. 3. a — c. Clymenia binodosa. pag. ~~10~~. 9
. 4. Cyrtocera cincta. pag. 34.
. 5. Cyrtocera costata. pag. 34.
. 6. a — c. Clymenia bilobata. pag. 11.
. 7. a — c. Clymenia ornata. pag. 122.
. 8. a — c. Porcellia retrorsa. pag. 38.
. 9. a — c. Clymenia Otto. pag. 31.

Tafel III.

. 1. Petraia decussata. pag. 43.
. 2. Petraia semistriata. pag. 43.
. 3. Petraia tenuicostata. pag. 44.
. 4. Petraia radiata. pag. 42.
. 5. Petraia Kochii. pag. 44.
. 6. Cidarites Nerei. pag. 40.
. 7. Goniatites planidorsatus. pag. 21.
. 8. Goniatites atratus. pag. 37.
. 9. Goniatites Verneuillii. pag. 17.
. 10. Sigillaria Sternbergii. pag. 47.

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Tafel XVI.

Fig. 1. Clymenia Dunkeri. pag. 15.
Fig. 2. Clymenia semicostata. pag. 13.
Fig. 3. Clymenia angulosa. pag. 12.
Fig. 4. Clymenia plicata. pag. 8.
Fig. 5. Clymenia cincta. pag. 9.
Fig. 6. Clymenia paradoxa. pag. 14.
Fig. 7. Asterocrinus Murchissoni. pag. 4

Tafel XVII.

Fig. 1. Goniatites subbilobatus. pag. 21.
Fig. 2. Goniatites subinvolutus. pag. 23.
Fig. 3. Goniatites Preslii. pag. 24.
Fig. 4. Goniatites clymeniaeformis. pag. 21
Fig. 5. Orthoceratites calamiteus. pag. 36
Fig. 6. Cyrtocera ungulata. pag. 35.

Tafel XVIII.

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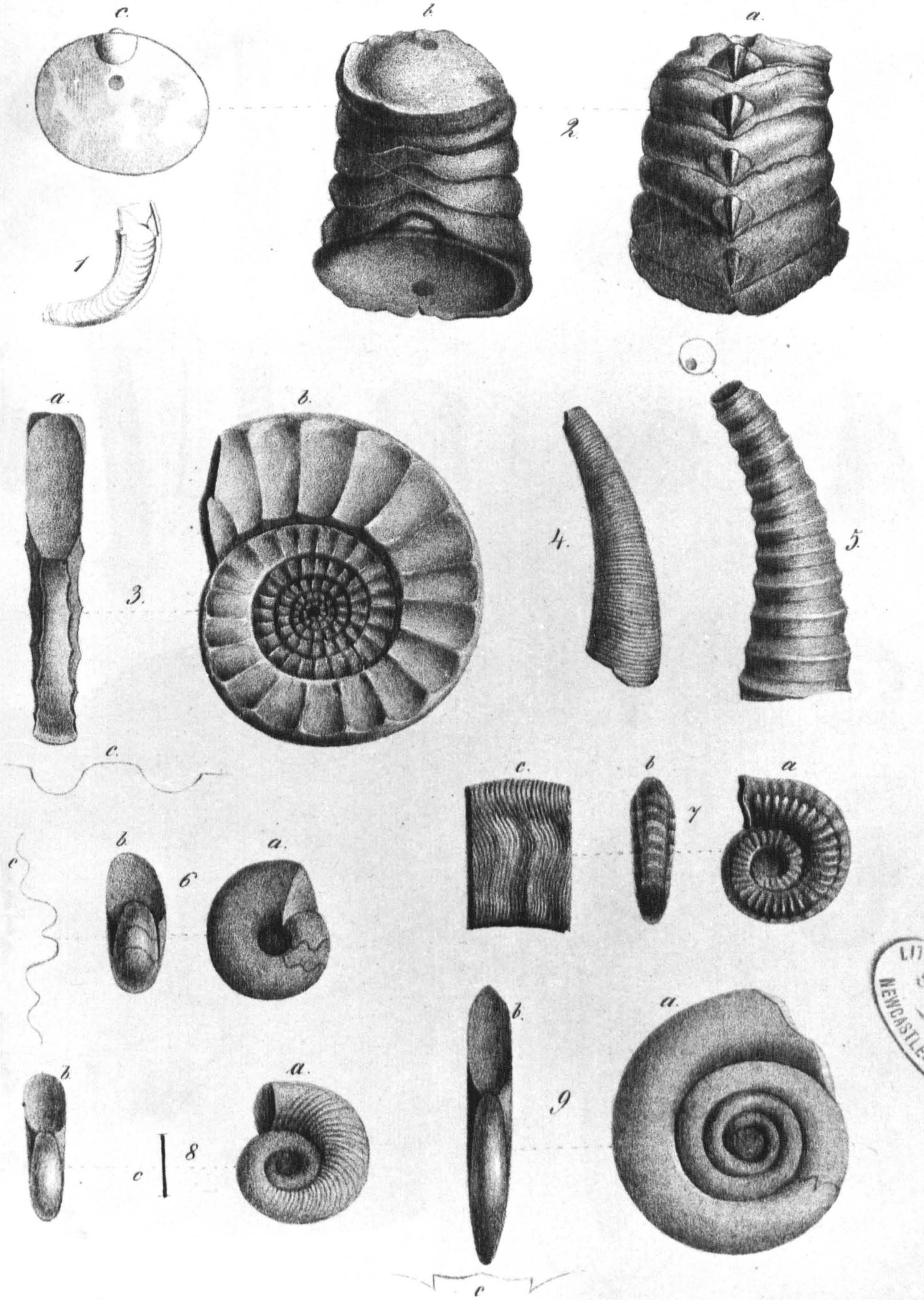

Lith: Anst. v. Schier in Lichtenfels.

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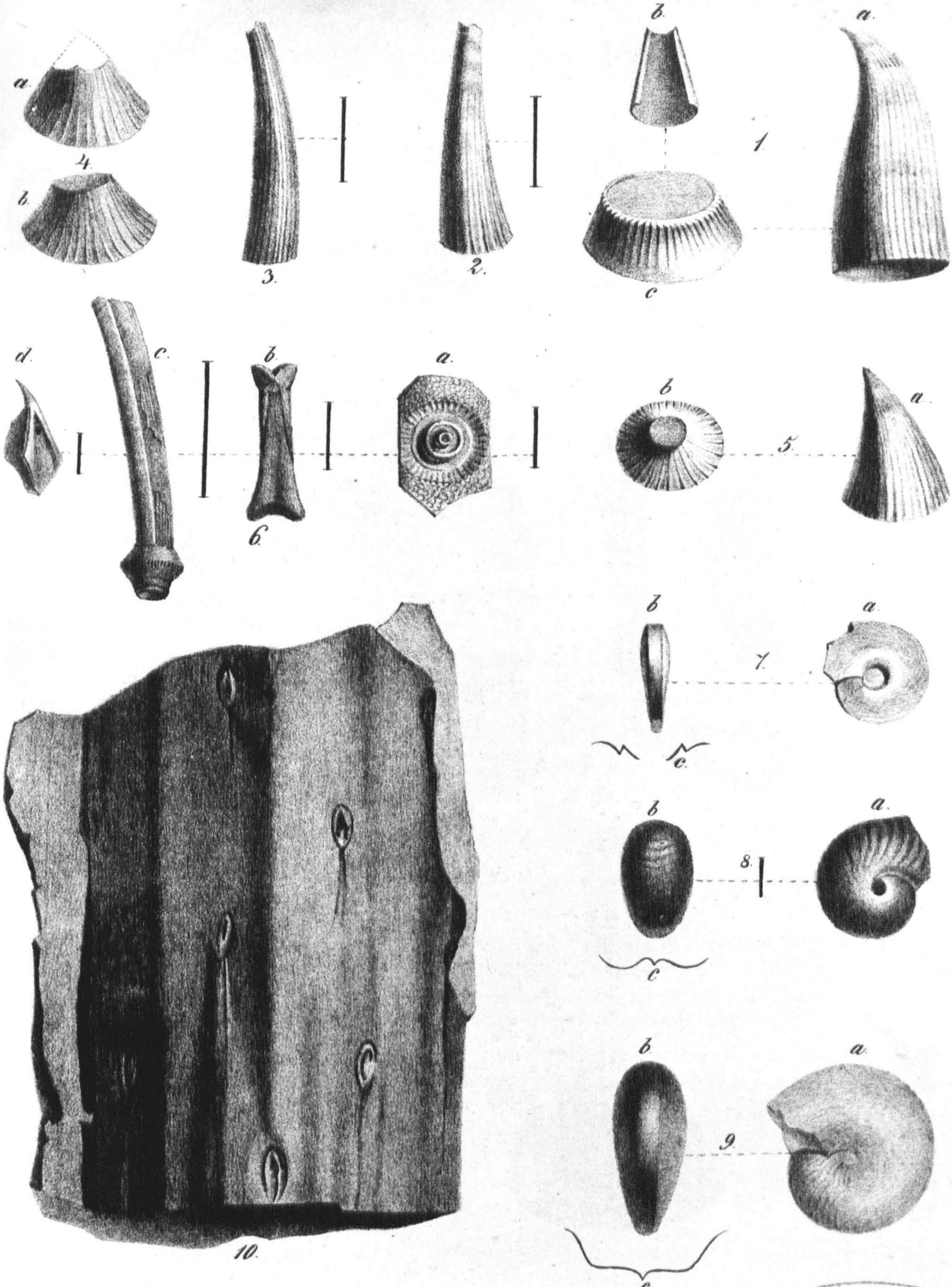
T.III.



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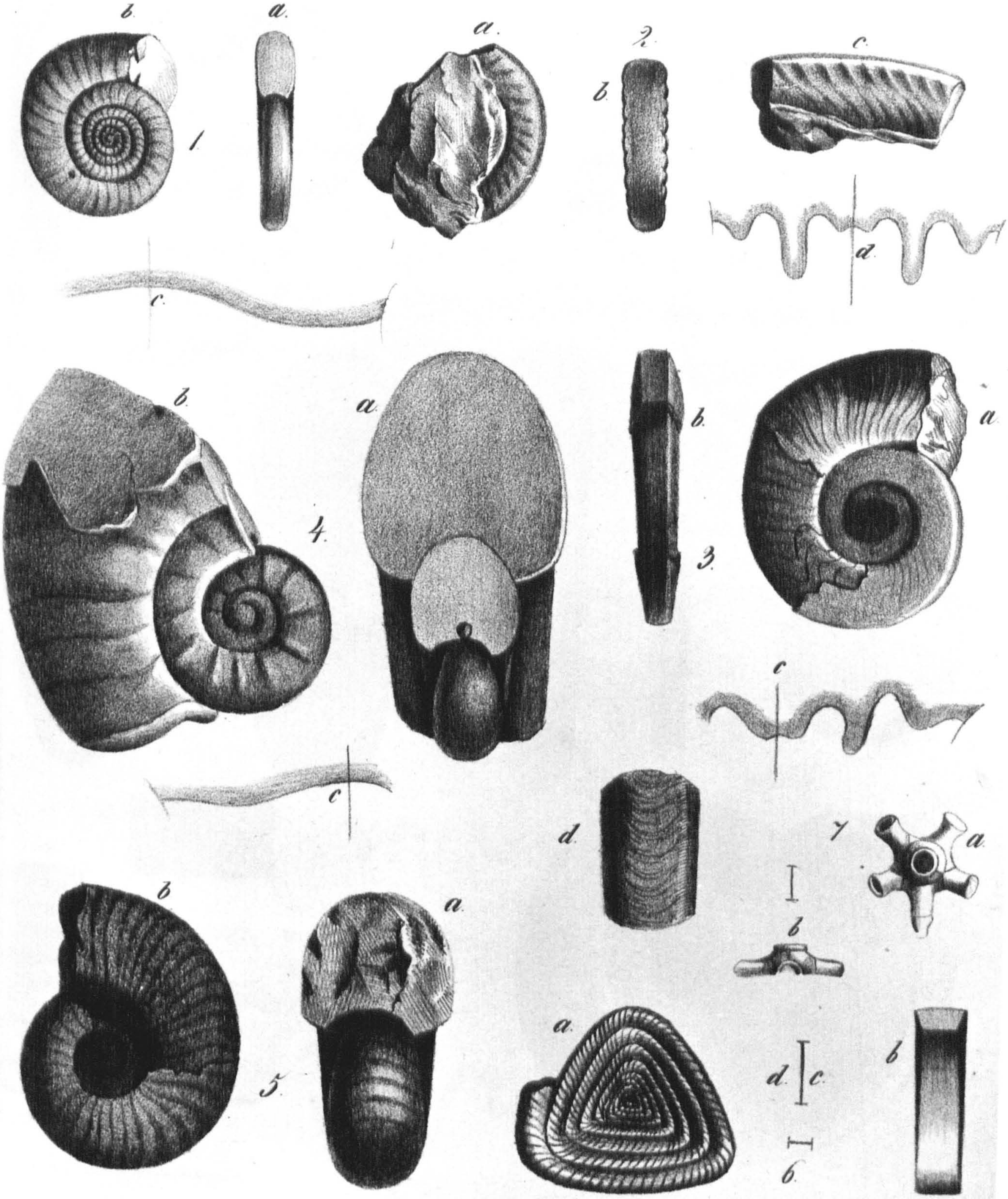

Lith. Anst. von Schier in Lichtenfels

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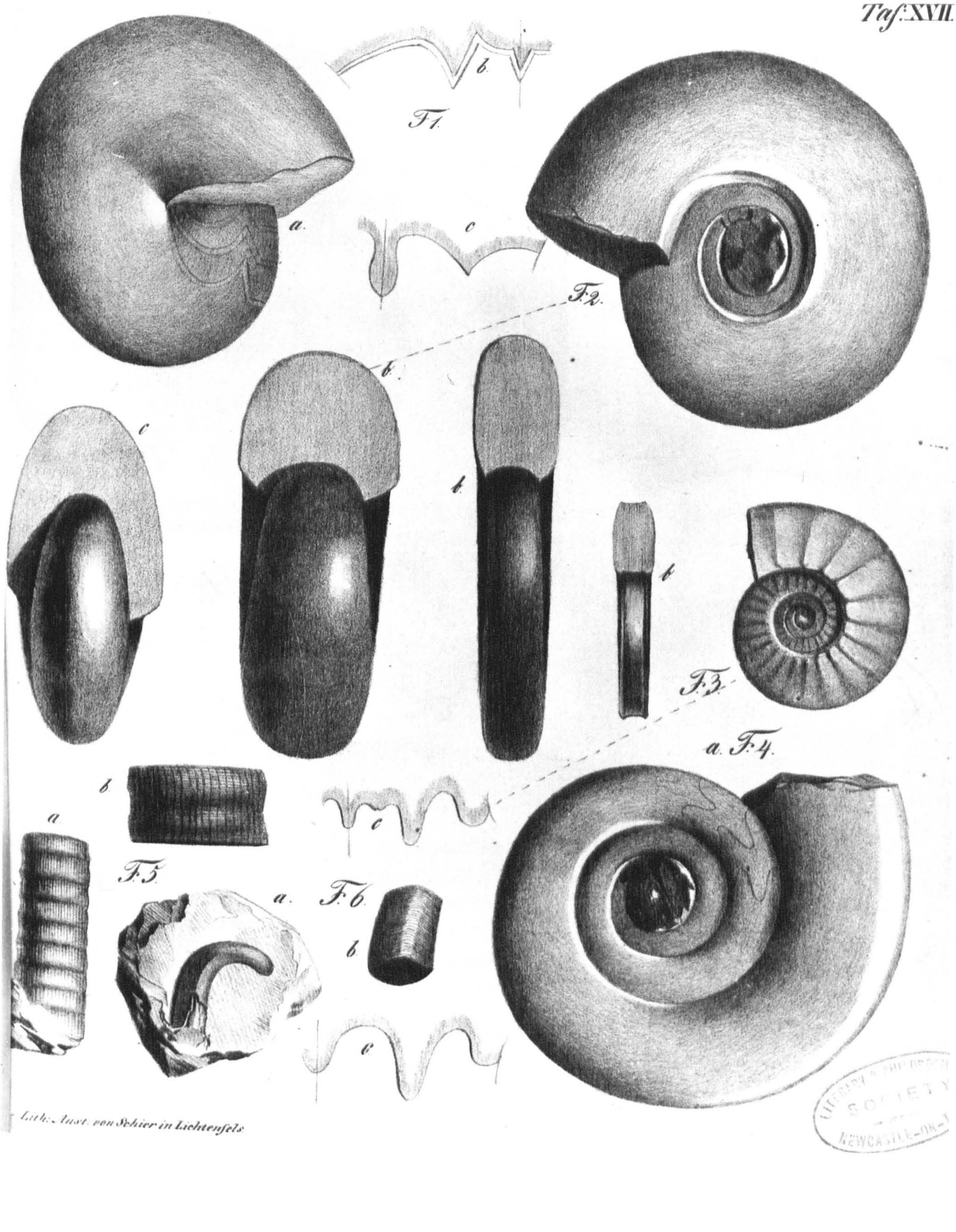
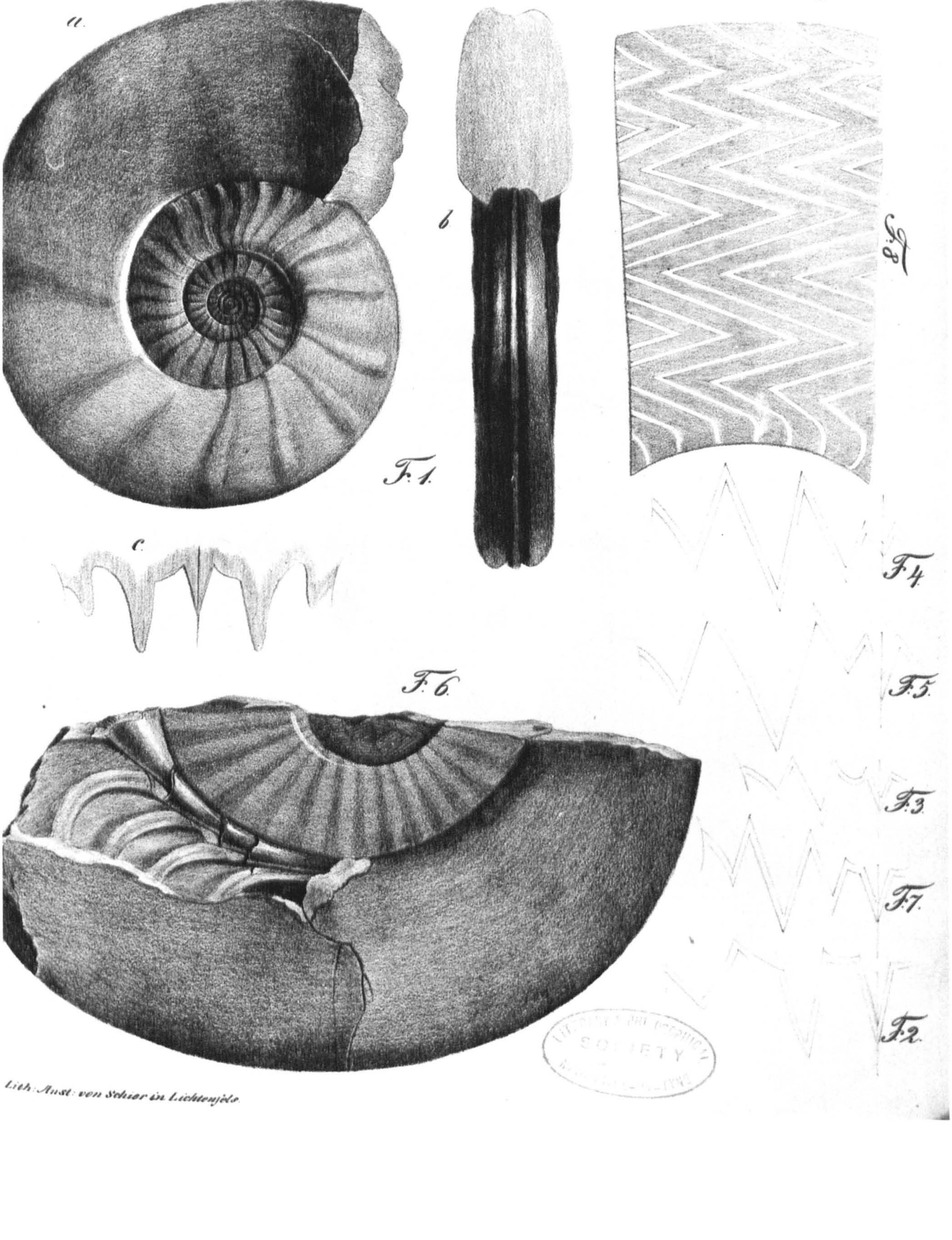
Taf. XVII.



Lith. Anst. von Schier in Lichtenfels.

Münster 1839

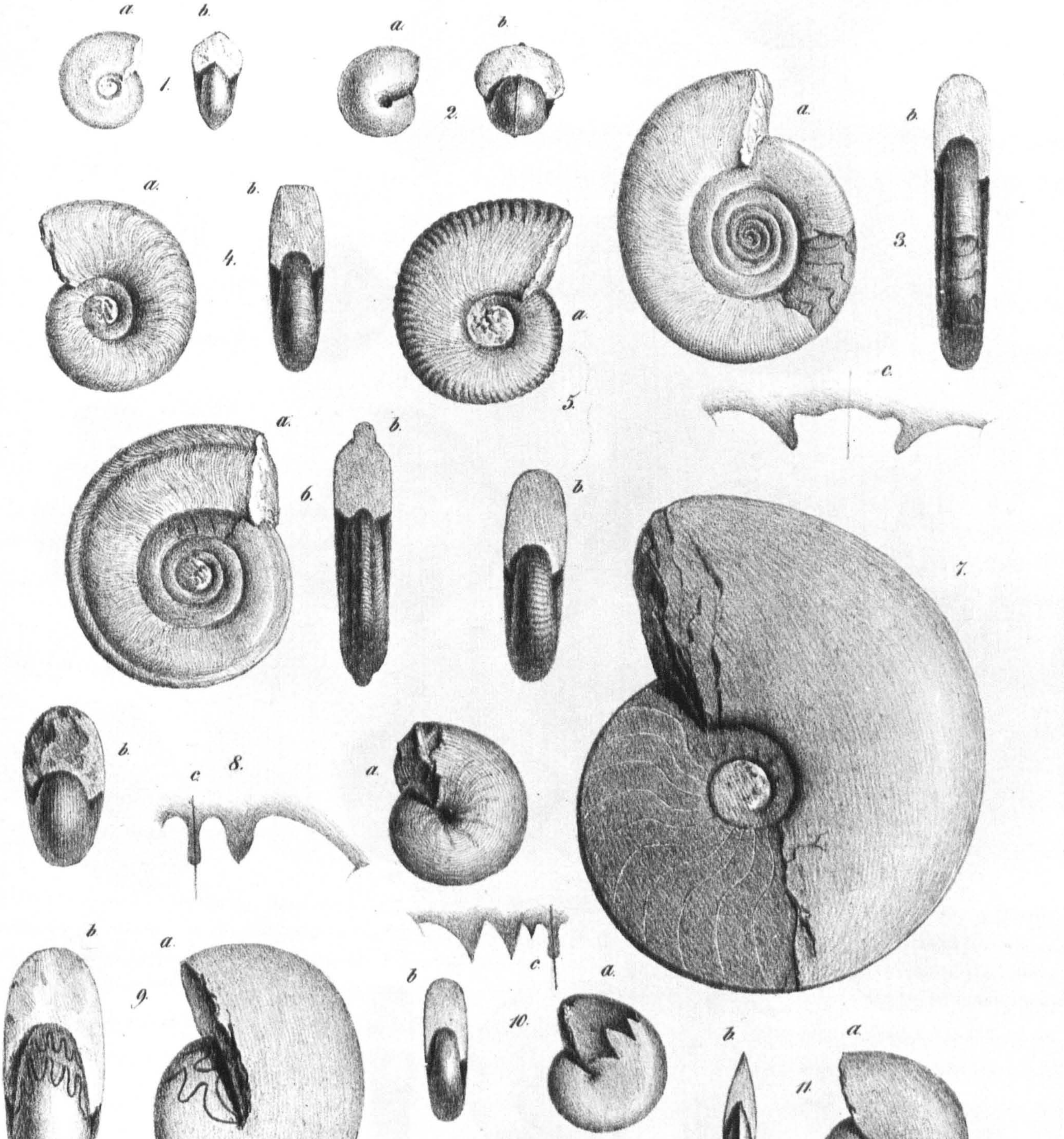
Taf: XVIII.



Lith: Anst: von Schier in Lichtenfels

Münster 1840

Taf. XVI



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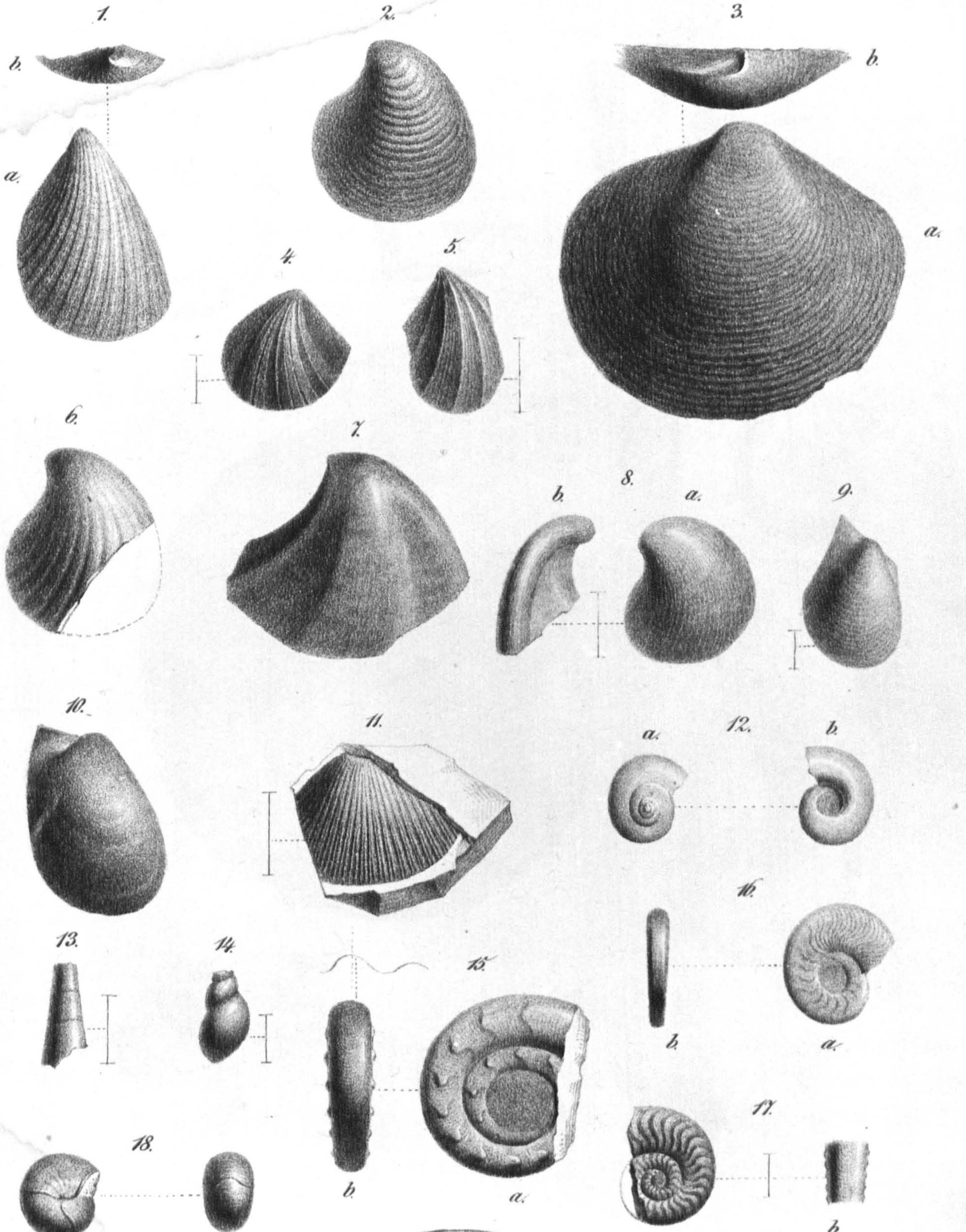
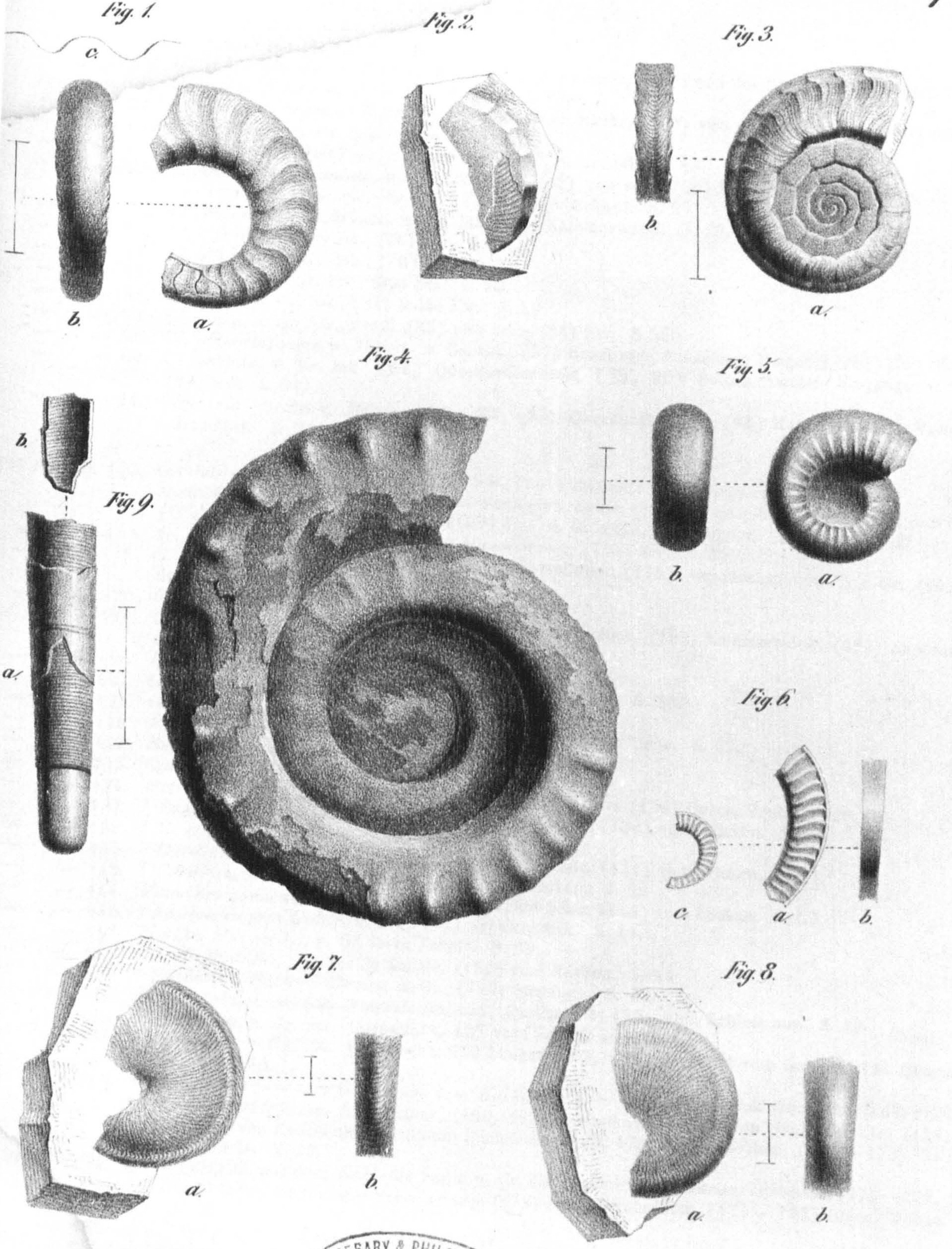
Taf. XI.



S. H. Jarwart ft.

Münster 1842

Taf. XII.



S. H. Jarwarth

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— — 75. *Cl. adversa*, n. Gr. Stk., (76) Kw. S. 29.
— — 77. *Cl. bilobata*, n. Gr. Stk., (78) Kw. S. 30.
— — 79. *Cl. sinuata*, n. Gr. Stk., (80) Kw. S. 30.
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— — 129. *G. sphaericus Mart.* Kammerwand. S. 37.
— — 130. *Pileolus dexter*, n. Gr. Stk vom Wirbel, (131) von der Seite. S. 37.
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— — 142. ? *Cardinia*, n. Gr., rechte Schale, (143) vom Rücken. S. 39.
— — 144. *Venulites concentricus C. Röm.*; n. Gr. rechte Seite, (145) vom Rücken. S. 39.
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— — 151. ? *Posidonia Becheri Bronn*, n. Gr., (152) Streifung. S. 43.
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— — 158. *Terebratula*, n. Gr. Stk. Dorsalseite, 159 Längenprofil, 160 Querprofil vom Schlofs, 161 Querprofil von d
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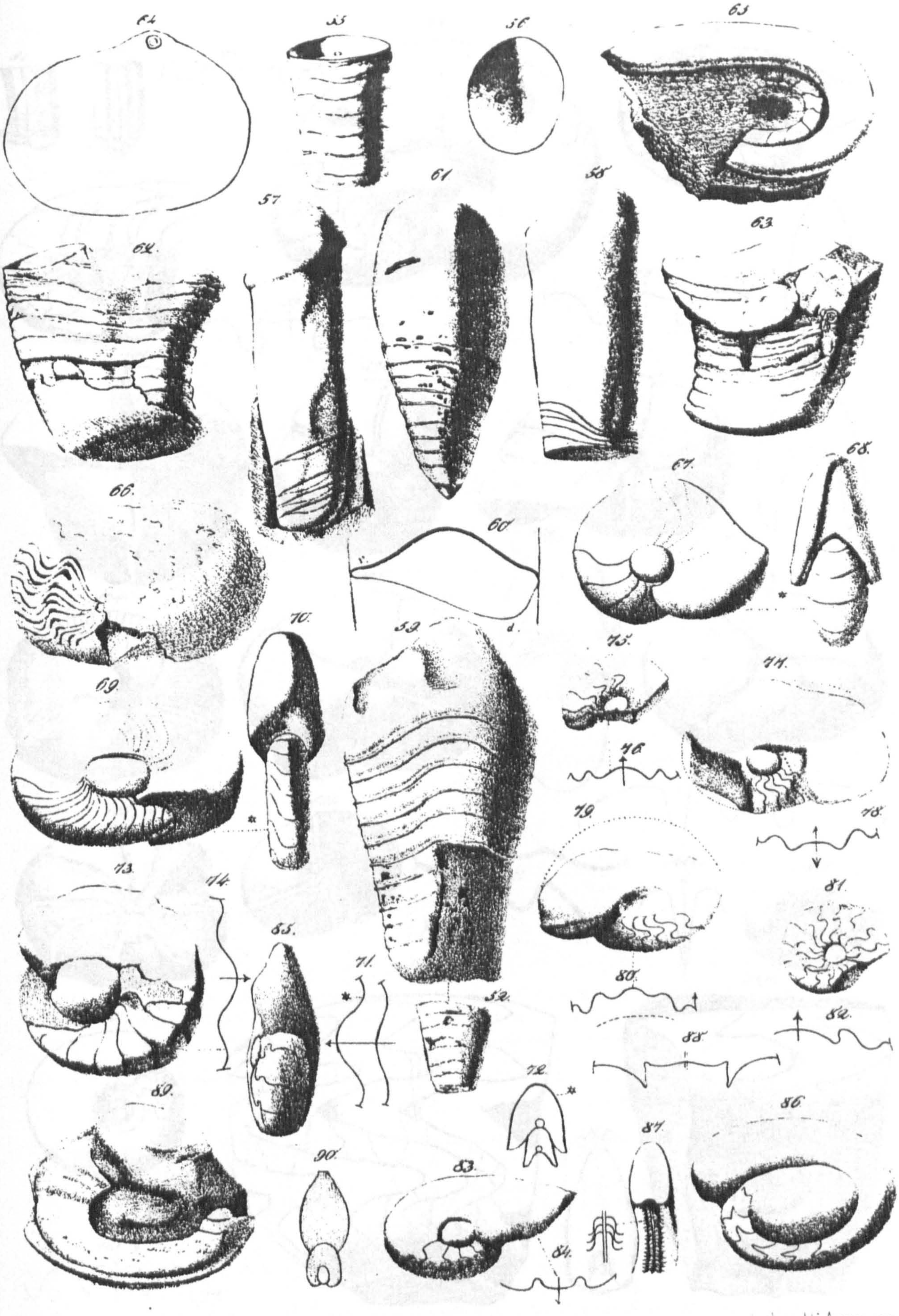
— — 184. Vgl. S. 41.
— — 185—204. Vgl. den *I. Anhang.* S. 42, 43.
— — 205. *Actinocrinus*, n. Gr. Kelch von unten, 206. Kelch von der Seite, 207. Kelchtafeln verkl., 208. Säulenstüc
209. Gelenkfläche. S. 46.
— — 210. *Delthyris*, vgr. S. 45.
— — 211. *Posidonomya*, vgr. S. 45.
— — 212 u. 213. Vgl. den *II. Anhang.* S. 46.

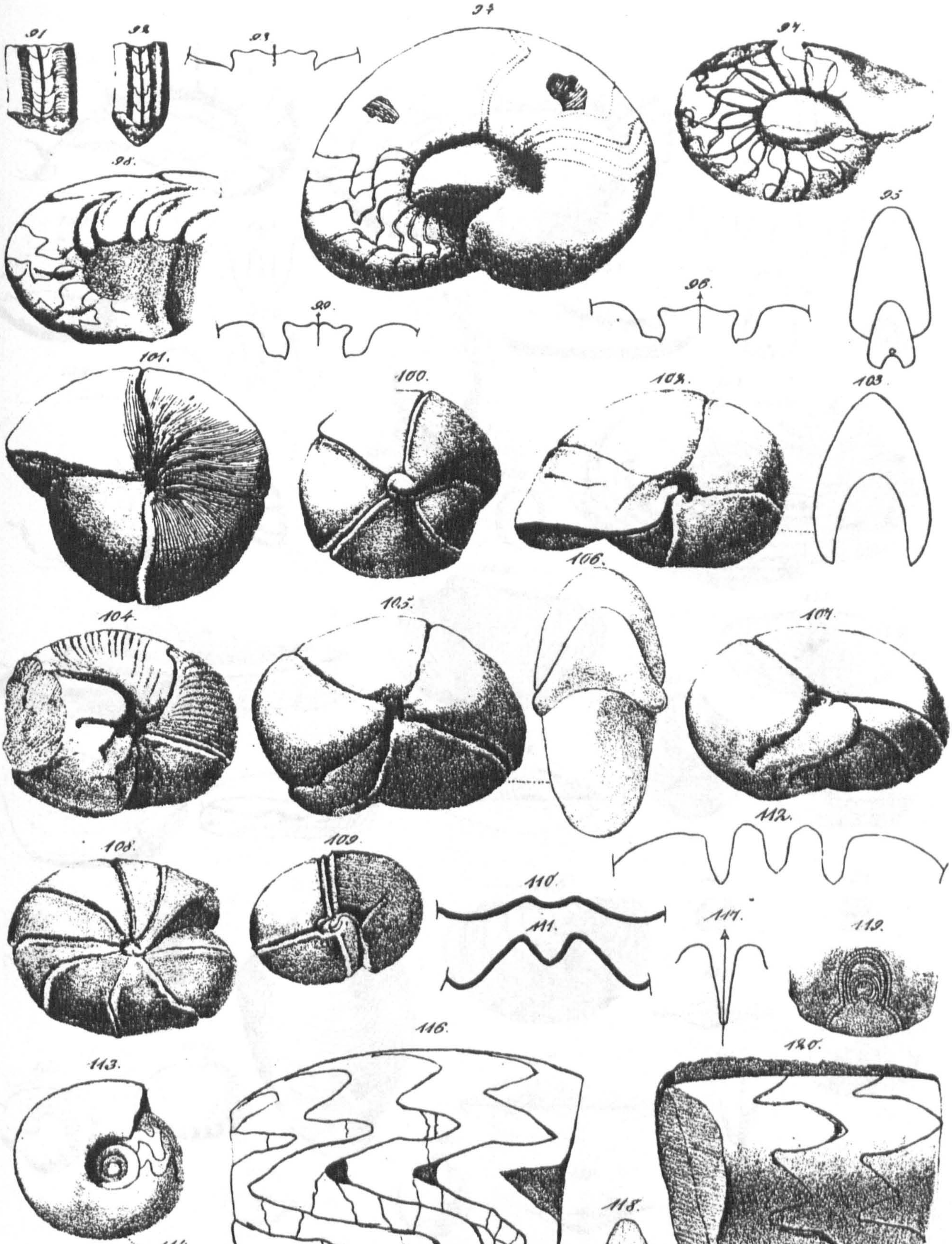


Gez. v. Dr. R. Richter.

Lith. v. E. Assmann.

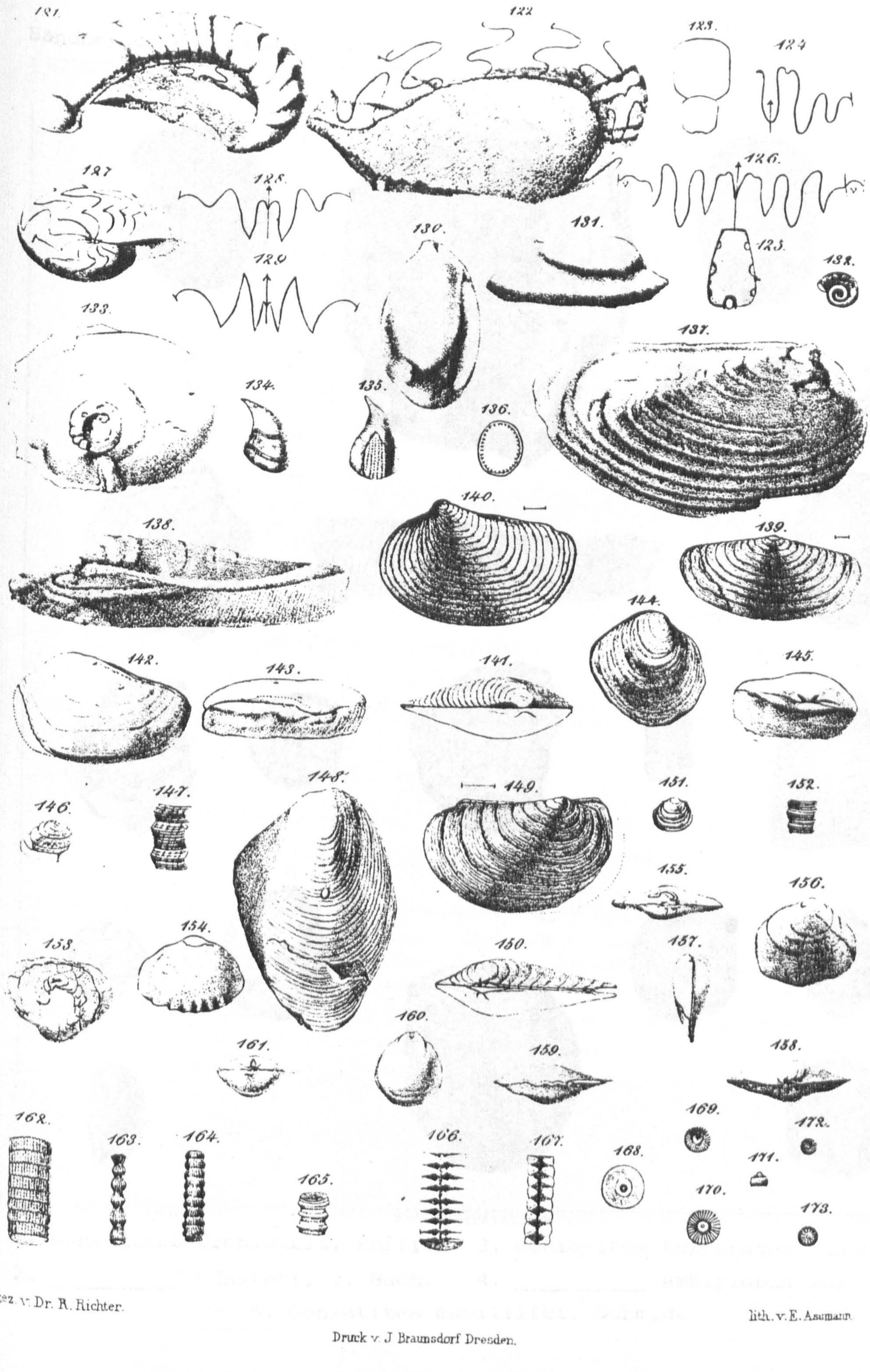
Druck v. J. Braunsdorf Dresden.

Fig. 91–120. Taf. IV.



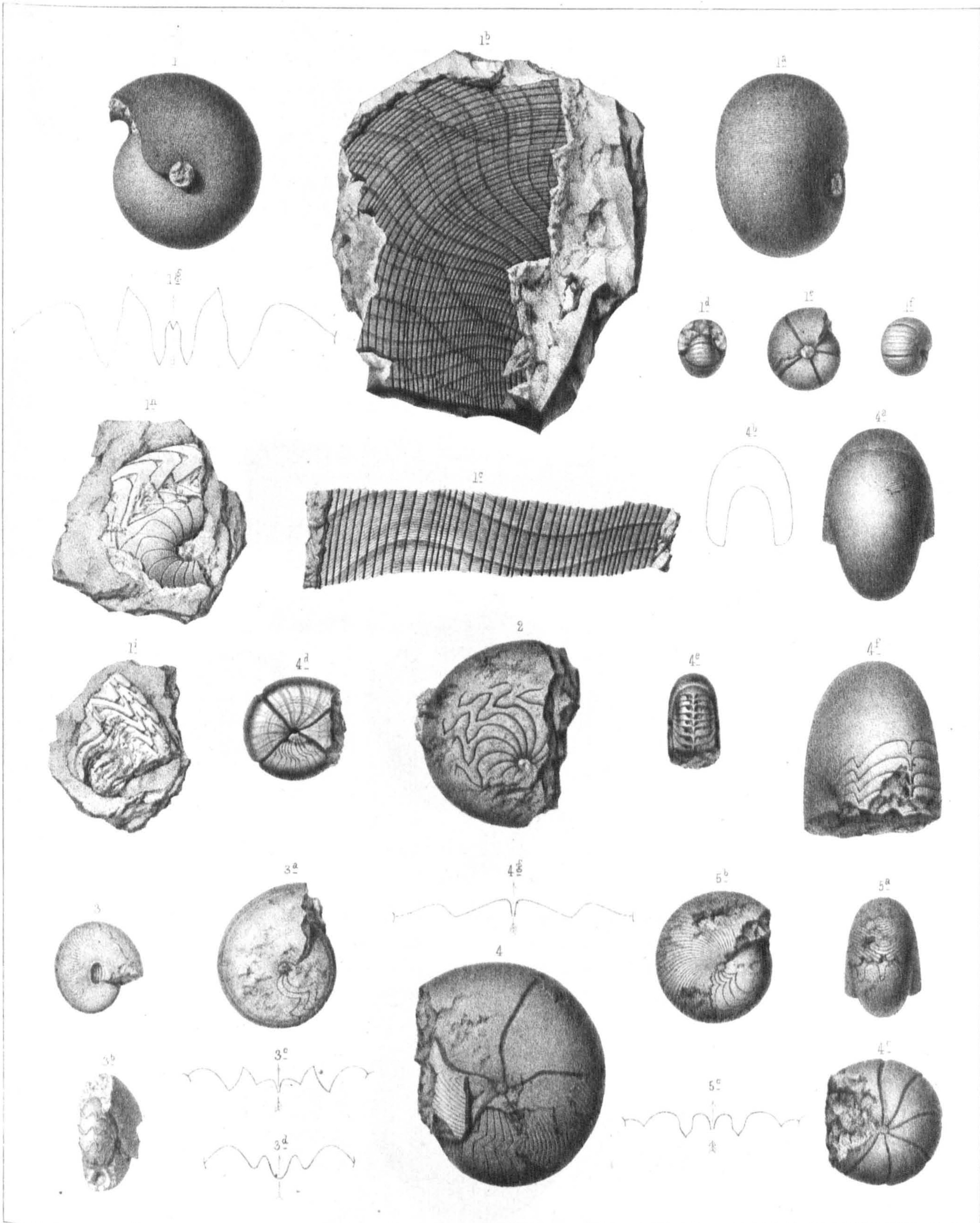
gez v Dr R. Richter. lith v E Assmann.

Druck v. J. Braunsdorf Dresden

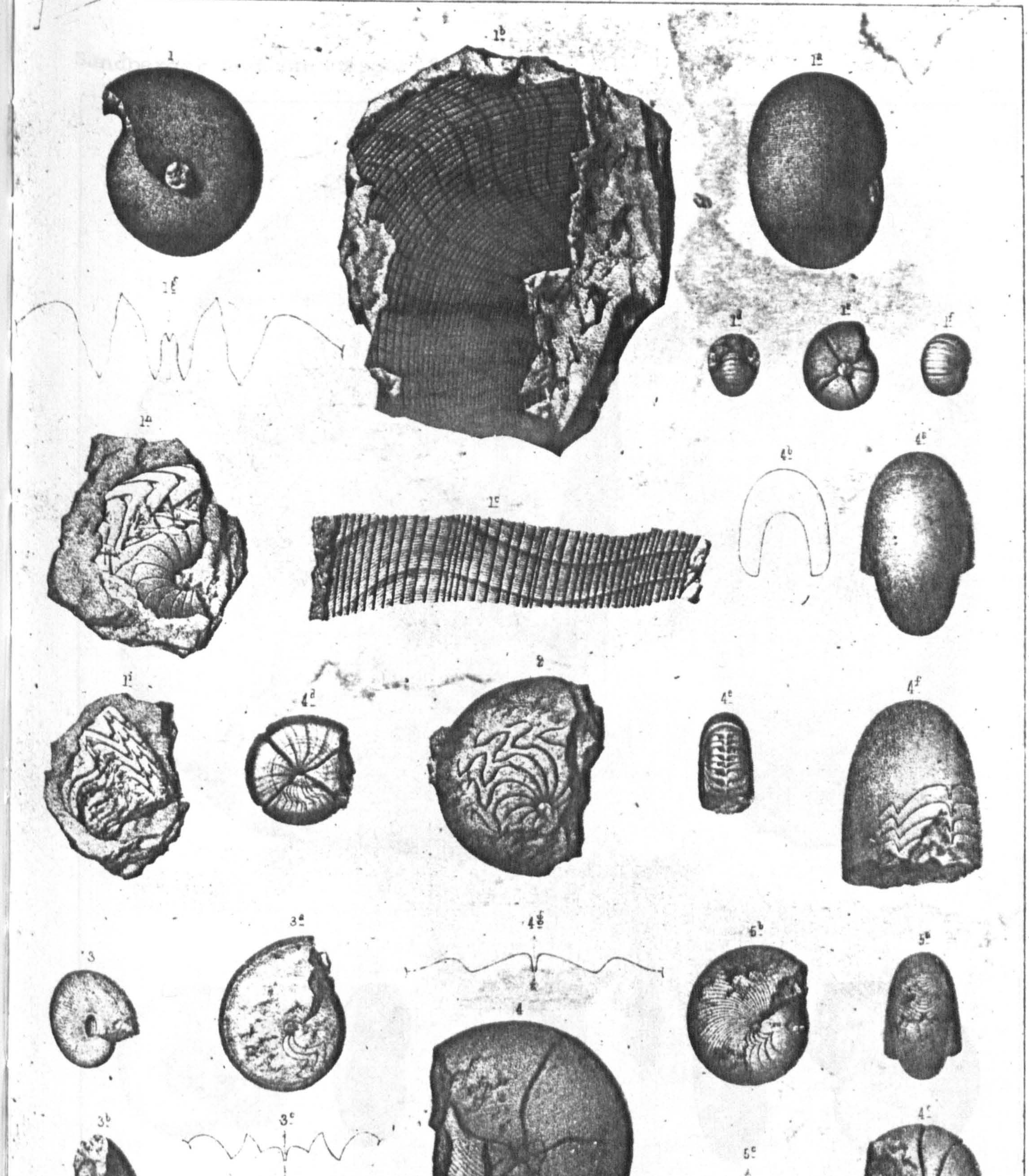


gez. v. Dr. R. Richter. lith. v. E. Assmann.

Druck v. J. Braunsdorf Dresden.



1. Goniatites crenistria, Phill. 3. Goniatites terebratus, Sandb.
2. ________? Münsteri, v. Buch. 4. ________ amblylobus id.
5. Goniatites mamillifer, Schmidt

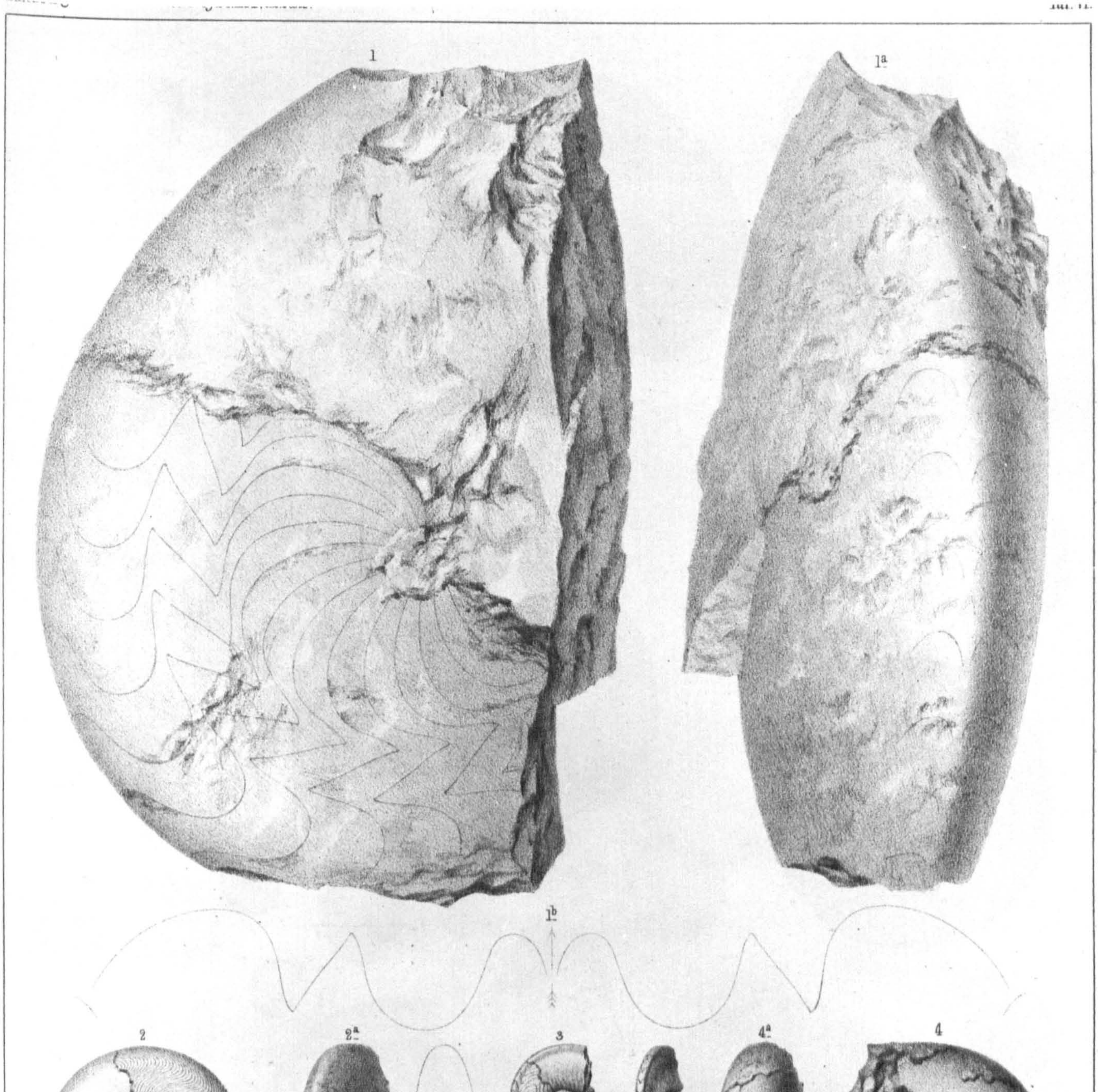


Lith. Anst. v. ? Leinhardt in Mainz. Wiesbaden, Verlag v. C. W. Kreidel. J. B. Kotz lith.

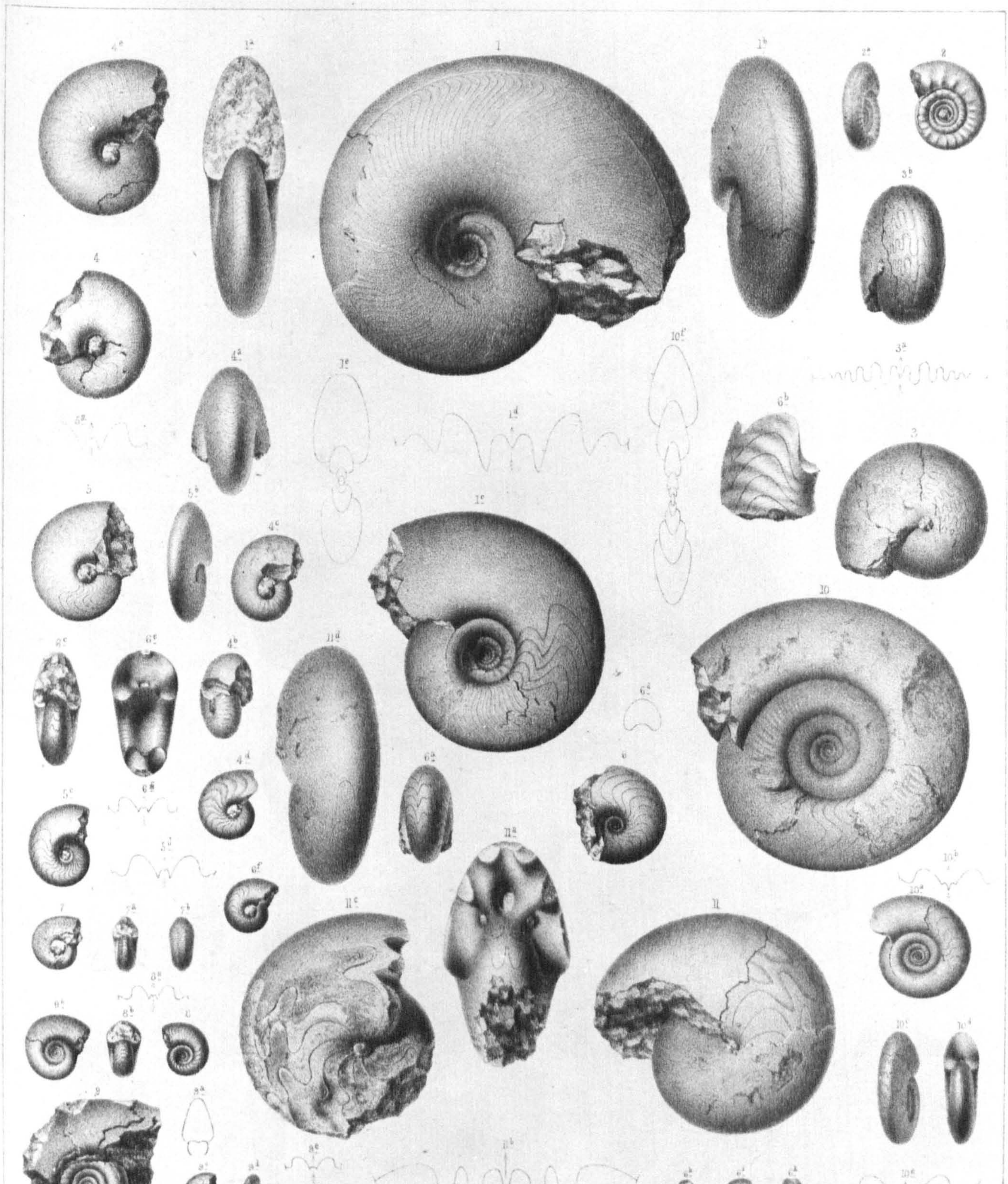
terebratus

1. *Goniatites crenistria, Thill.*
2. ——— *? Münsteri, v. Buch.*
3. *Goniatites terebratus Sandb.*
4. ——— *amblylobus id.*
5. *Goniatites mamillifer, Sandb.*

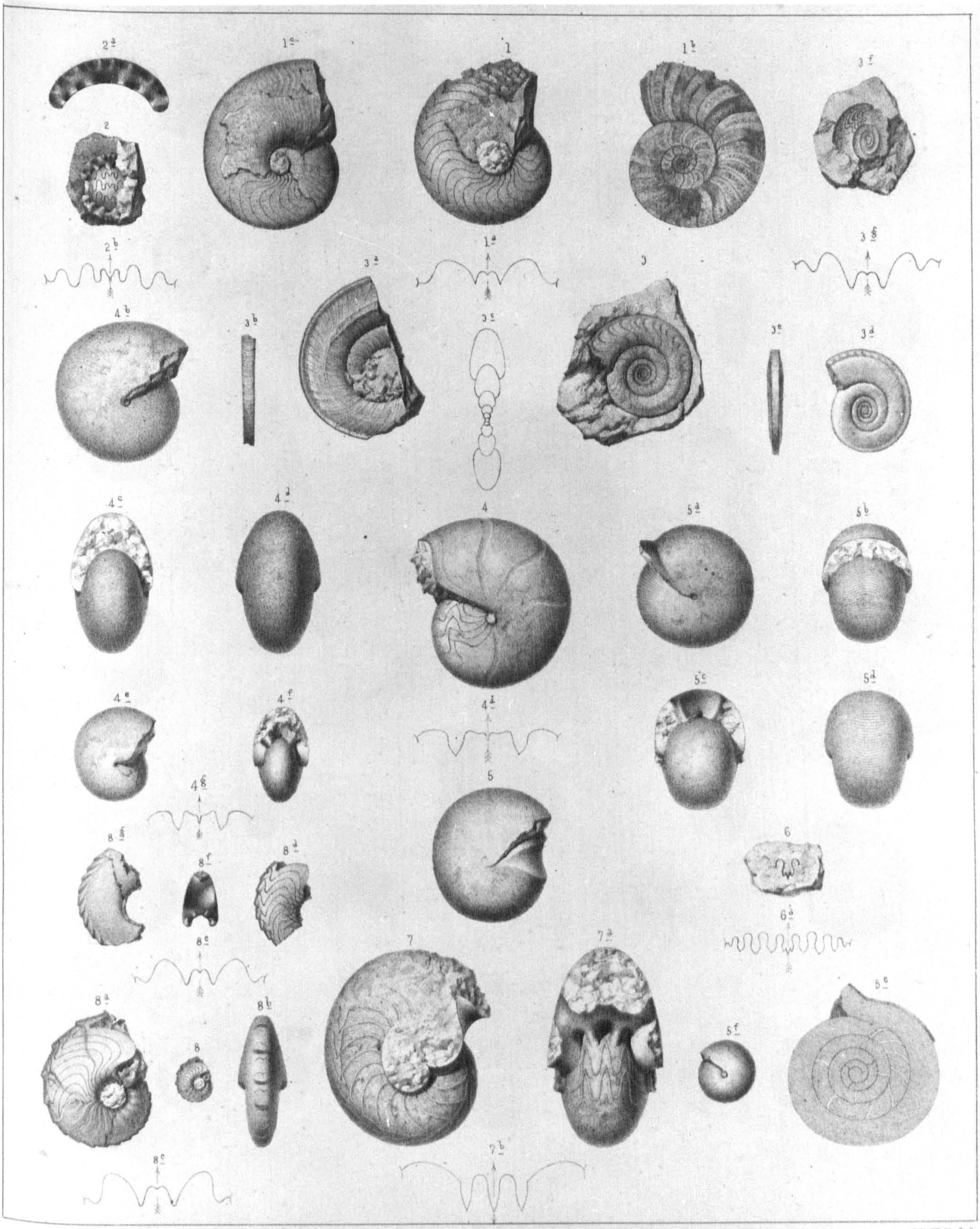
mamillifer



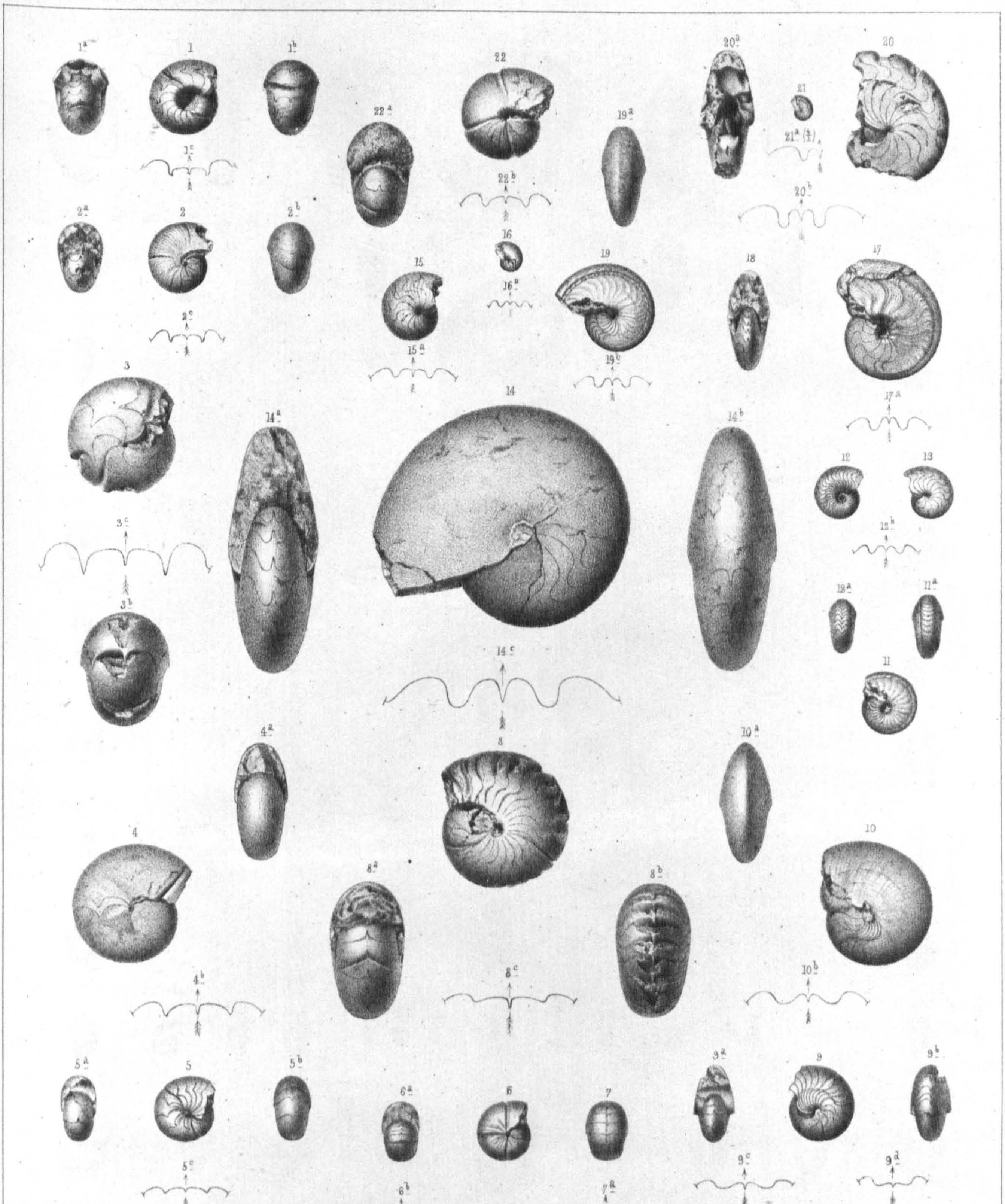
1. Goniatites acuto-lateralis, Sandb. 3. Goniatites forcipifer, Sandb.
2. __________ sublamellosus, id. 4. __________ carinatus, Beyr.



1. G. lamellosus, Sandb. 2. G. tuberculoso-costatus, D'Arch et De Vern. 3. G. clavilobus, Sandb. 4. G. lamed, id. Var. rugosus. 5. G. lamed, Sandb. Var. complanatus. 6. G. Var. cordatus. 7. G. Var. tripartitus. 8. G. Var. latidorsalis. 9. G. Var. calculiformis (Beyr.). 10. G. aequabilis, Beyr. 11. G. bidens, Sandb.

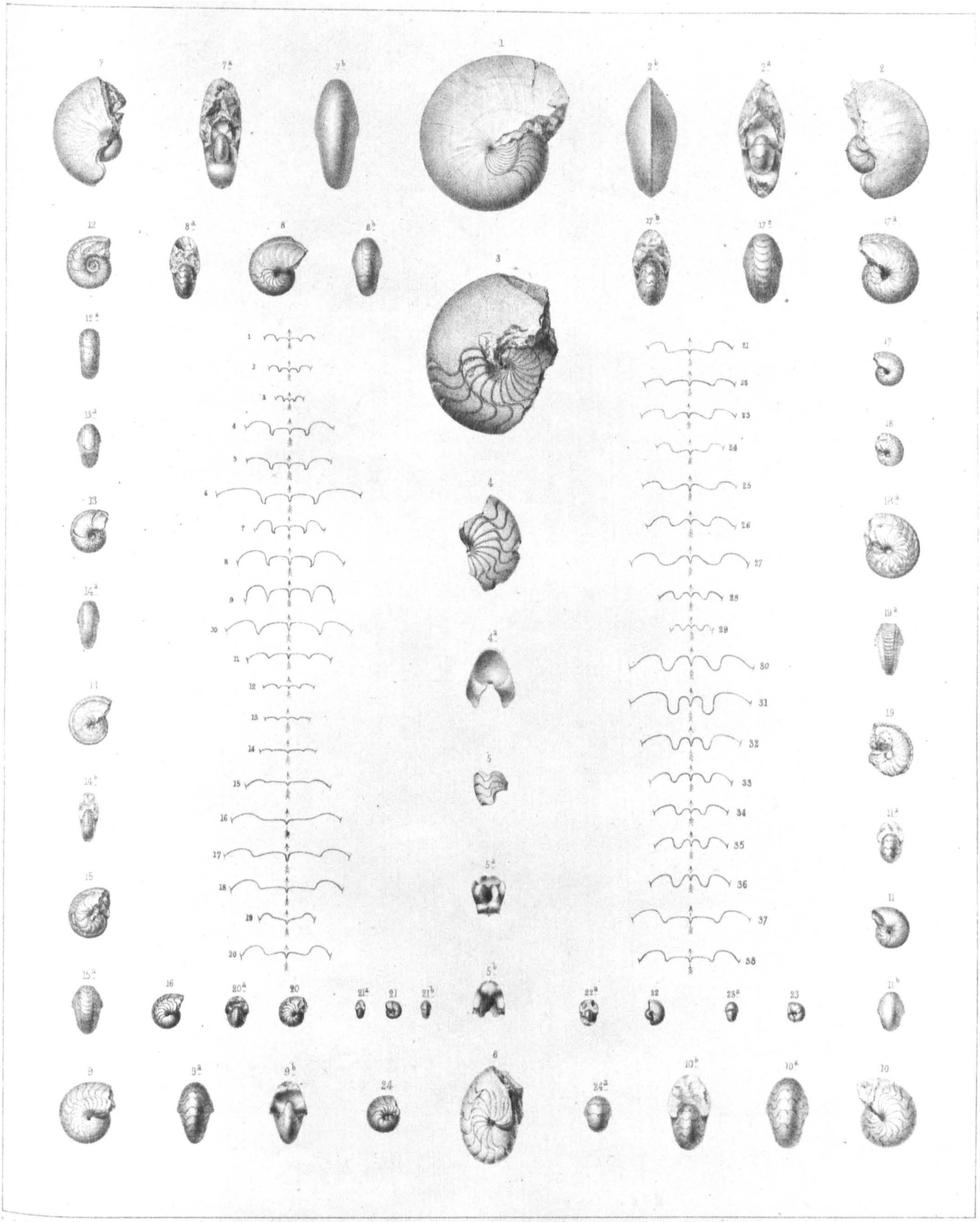


1. Goniatites carinatus, Beyr.
2. ______ tridens, Sandb.
3. ______ Planorbis, id.
4. ______ bifer, Phill.
5. Goniatites bifer, Phill. Var. Delphinus, Sandb.
6. ______ mixolobus, Phill.
7. ______ bilanceolatus, Sandb.
8. ______ serratus, Stein.



Goniatites retrorsus, v. Buch

1. umbilicatus
2. curvispina
3. oxyacantha
4. angulatus
5. biarcuatus
6,7. planilobus
8. amblylobus
9. circumflexus
10. acutis
11,12,13. auris
14,15,16. retrorsus typus
17,18,19. undulatus
20,21. lingua
22. sacculus

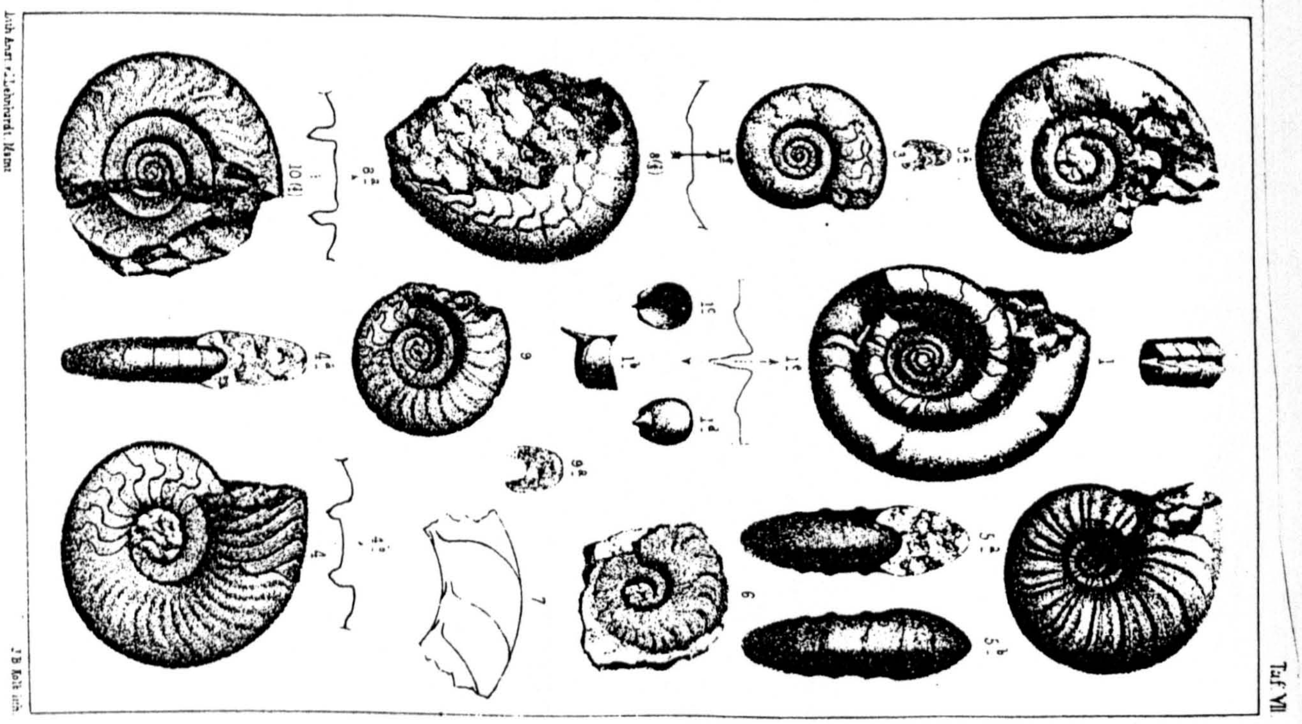


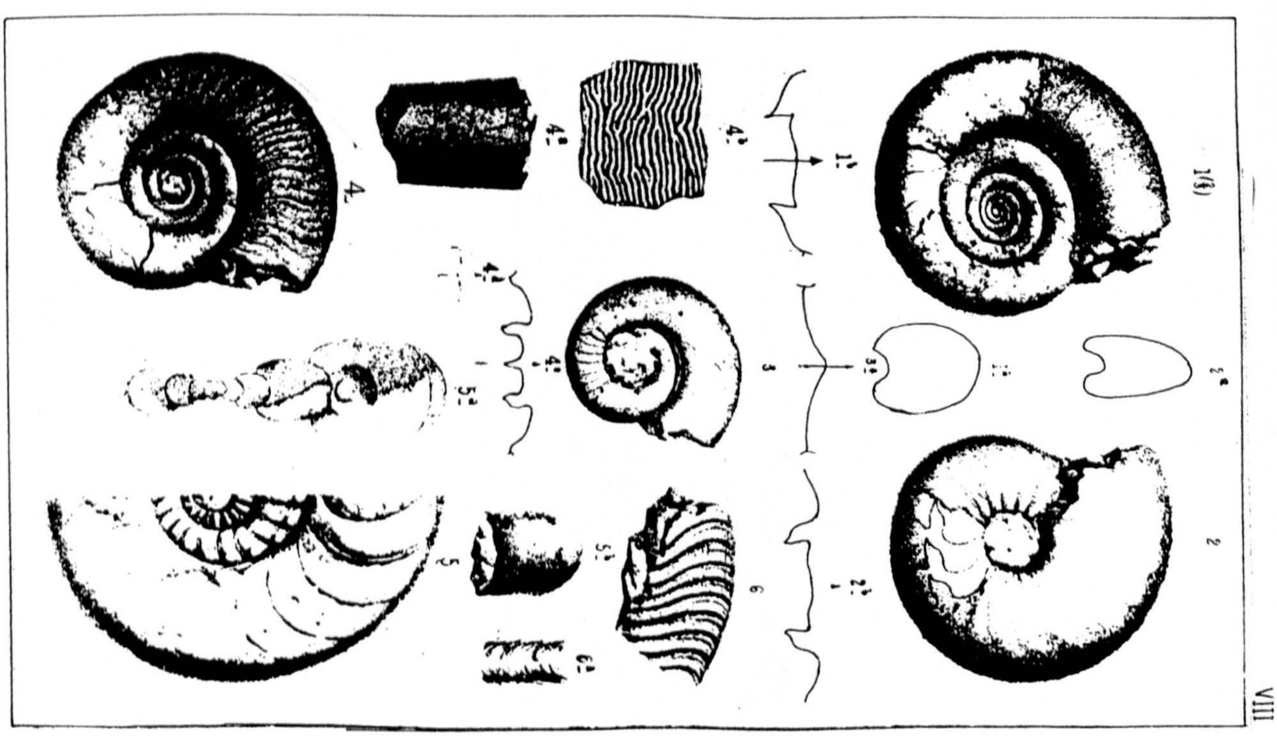
A. Kolb lith

Goniatites retrorsus, v. Buch

1,2.	acutus	7.	undulatus	8,12-19.	auris		
3-6,10,11.	retrorsus typus	9.	circumflexus	20,23,24.	amblylobus		

Sandberger 1853b





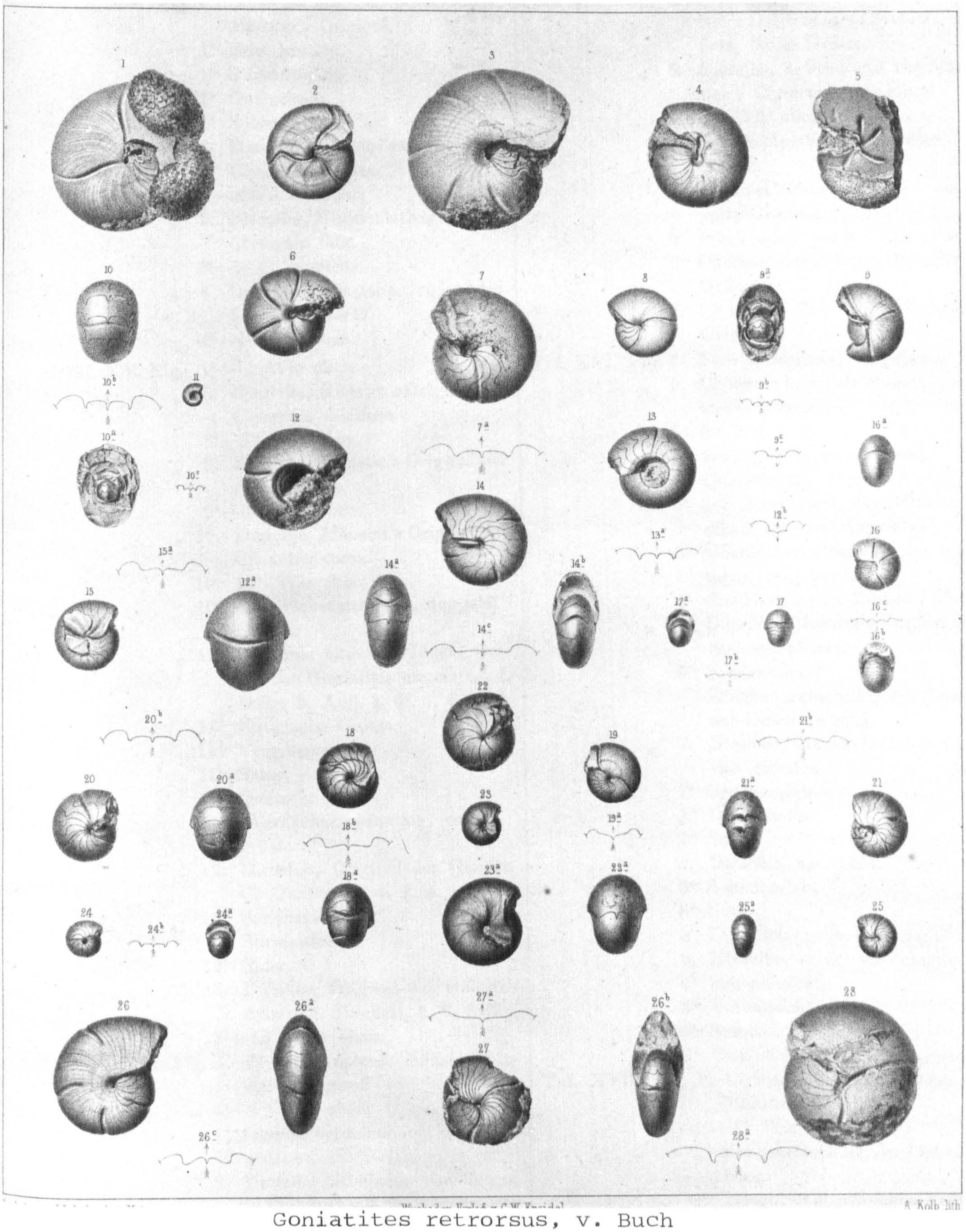
Taf. VII.

Fig. 1. Clymenia laevigata von Warstein.
1a. Ein Stück derselben mit den ventralen Siphonalloben;
1b, 1c, 1d. Dreierlei Ansichten einer einzelnen Kammer;
1e. Sutur, vom Bauch bis in die Rückenlinie;
1f. Sutur, vom Rücken bis in die Bauchgrenze.
2. Cl. pseudogoniatites. Enkeberg.
3. Desgl. 3a. Querschnitt.
4. Desgl. 4a. Ansicht von vorn.
4b. Sutur, etwas abgerieben.
5. Cl. arietina. Enkeberg.
5a. Von vorn. 5b. Vom Rücken aus.
6. Cl. pseudogoniatites, ganz mit Schale bedeckt.
7. Ein Stück von einem Schliff auf die Windungsebene, welcher die Siphonalduten derselben Art und zwar der stark gefalteten Varietät (von Taf. VIII. Fig. 6) zeigt.
8. Cl. striata, Steinkern aus einem Kalkknauer des Cypridinenschiefers von Saalfeld. $\frac{2}{3}$ der natürl. Grösse.
9. Cl. pseudogoniatites, theils Steinkern mit Loben, theils mit stark abgeriebenen Schalenparthieen.
10. Dieselbe Art mit wohlerhaltener Schale und zur Hälfte mit dem Abdruck derselben.

Taf. VIII.

Fig. 1. Clymenia undulata ($\frac{2}{3}$ Grösse) von Ebersdorf.
1a. Querschnitt.
1b. Sutur.
2. Cl. striata ebendaher.
2a. Querschnitt.
2b. Sutur.
3. Cl. compressa (Var. angustiseptata) vom Enkeberg.
3a. Sutur.
4. Cl. pseudogoniatites ebendaher.
4a. Ein Stück Steinkern desselben, vom Rücken gesehen, mit Dorsalloben, welche sich aber unten völlig schliessen sollten. Nicht ganz correct gezeichnet. S. oben Text.

4b. Runzelschicht, stark vergrössert.
4c. Unverletzte äusserliche Sutur.
4d. Dorsalgegend derselben bei einem etwas abgeriebenen Exemplare.
Fig. 5. Clymenia binodosa vom Enkeberg.
5a. Schliff durch den Mittelpunkt auf die Querschnittebene.
5b. Eine Kammer, vom Rücken gesehen, nebst einem Stück von deren Querscheidewand.
6. Starkfaltiges Schalenstück von Clymenia pseudogoniatites, von der Seite gesehen.
6a-7. Rückengegend desselben Exemplares.



Goniatites retrorsus, v. Buch

1-6,8,14,15,18,19,23,25. amblylobus
7,20,22. sacculus 11,12,13. umbilicatus 26. circumflexus
16,17. biarcuatus 9,10,24,28. curvispina 27. planilobus

Taf. XV. Fig. 1. Clymenia angustiseptata Münst., Münster's Original.
1ᵃ. Seitenansicht.
1ᵇ. Stirnansicht.
1ᶜ. Querschnitt.
1ᵈ. Suturen.
„ 2. Dieselbe, Münster's Original der Clymenia plicata.
2ᵃ—2ᶜ. Wie oben.
„ 3. Dieselbe, Münster's Original der Clymenia lata.
3ᵃ—3ᶜ. Wie oben.
„ 4. Dieselbe, Münster's Original der Clymenia cincta.
4ᵃ—4ᶜ. Wie oben.

Taf. XV. Fig. 5. Dieselbe, Querschnitt zu Münster's Original der Clymenia inflata, halbe Grösse.
„ 6. Dieselbe, in der Form von Münster's Clymenia subnodosa.
6ᵃ—6ᶜ. Wie oben.
6ᵈ. Schalenoberfläche, doppelte Grösse.
6ᵉ. Runzelschicht und Kiel, doppelte Grösse.
6ᶠ. Stück eines zweiten Exemplars.
6ᵍ. Oberflächenstreifung, doppelte Grösse.
„ 7. Clymenia flexuosa, Münster's Original.

Taf. XV. Fig. 7ᵃ—7ᵈ. Wie oben.
„ 8. Dieselbe, Münster's Original der Clymenia falcifera.
8ᵃ—8ᵈ. Wie oben.
„ 9. Dieselbe, Münster's Original der Cl. costulata.
9ᵃ—9ᵈ. Wie oben.
„ 10. Dieselbe, Münster's Original der Cl. subflexuosa.
10ᵃ. 10ᵇ. Wie oben.
10ᶜ. Oberflächenstreifung, doppelte Grösse.
„ 11. Clymenia annulata Münst., Orinal des Goniatites annulatus. I. Beitr. 2. Aufl. t. 6ᵃ. f. 6.
11ᵃ. Natürliche Grösse.
11ᵇ. Vergrössert.
11ᶜ. Sutur.
11ᵈ. Querschnitt.
11ᵉ. Oberflächenzeichnung, vergrössert.
„ 12. Dieselbe, Original der Geinitz. Cl. Dunkeri, t. 9. f. 4.
12ᵃ. Seitenansicht.
12ᵇ. Stirnansicht.
12ᶜ. Sutur.
„ 13. Dieselbe, Original der Geinitz'schen Cl. Dunkeri, t. 9. f. 5.
13ᵃ—13ᶜ. Wie oben.

Taf. XVI. Fig. 1. Clymenia spinosa Münst., Münster's Original.
1ᵃ—1ᶜ. Wie oben:
1ᵈ. Oberflächenzeichnung, vergrössert.
„ 2. Dieselbe in einem von Braun in Bayreuth als Cl. penicellata mitgetheilten Exemplar.
2ᵃ—2ᵈ. Wie oben.
„ 3. Clymenia Dunkeri Münst., Münster's Original.
3ᵃ—3ᶜ. Wie oben.
„ 4. Dieselbe, zweites Exemplar von Geuser.
4ᵃ. 4ᵇ. Wie oben.

Taf. XVI. Fig. 4ᶜ. Schalenstreifung, vergrössert.
„ 5. Clymenia laevigata Münst., Münster's Original.
5ᵃ. 5ᵇ. Wie oben.
5ᶜ. Sutur mit Siphonal-Lobus.
5ᵈ. Querschnitt.
5ᵉ. ein Bruchstück der Münster'schen var. semicingulata.
5ᶠ. Oberflächenzeichnung der letzteren, vergrössert.
5ᵍ. eine Kammer mit Siphonal-Dute.
„ 6. Dieselbe, Münster's Original der var. semiplicata.
6ᵃ. Seitenansicht.
6ᵇ. Längendurchschnitt, die Siphonal-Duten zeigend.
„ 7. Dieselbe, Münster's Original der var. elliptica.
7ᵃ. Seitenansicht.
7ᵇ. Querschnitt.
7ᶜ. Sutur.
„ 8. Dieselbe, var. nana.
8ᵃ. Seitenansicht.
8ᵇ. Sutur.
8ᶜ. Ein Stück mit der Runzelschichte.
„ 9. Dieselbe, in der var. cingulata.
9ᵃ. Seitenansicht.
9ᵇ. Stirnansicht.
9ᶜ. Sutur.
9ᵈ. Oberflächenzeichn., vergrössert.

Taf. XVII. Fig. 1. Clymenia undulata Münst., Münster's Original.
1ᵃ—1ᵈ. Wie oben.
1ᵉ. Kammerstück mit der Siphonal-Dute.
1ᶠ. Desgl. mit dem Siphonal-Lobus.
1ᵍ. Ein angeschliffenes Exemplar mit den Kammerwänden.
1ʰ. Ansicht der Extern-Seite mit der Runzelschicht.
1ⁱ. Extern-Fläche mit dem Kiel der Runzelschicht.
1ᵏ. Runzelschicht und Kiel, vergrössert.

Taf. XVII. Fig. 2. Dieselbe, Münsters Original der Cl. sublaevis.
2a. 2b. Wie oben.
2c. Oberflächenzeichnung, vergrössert.
" 3. Dieselbe, Münsters Original der Cl. linearis.
3a. 3b. Wie oben.
" 4. Dieselbe, Münster's Original der Cl. inaequistriata.
4a. 4b. Seitenansicht und Sutur.
" 5. Dieselbe, Münster's Original der Cl. similis.
5a. Seitenansicht.
5b. Oberflächenzeichnung, vergrössert.
5c. Sutur.
" 6. Dieselbe, Münster's Original der Cl. semistriata.
" 7. Dieselbe, Münster's Original der Cl. pygmaea.
7a. 7b. Seiten- und Stirnansicht.
7c. Sutur.
" 8. Dieselbe, Münster's Original der Cl. tenuistriata.
8a—8c. Wie oben.
8d. Oberflächenzeichnung, vergrössert.
" 9. Dieselbe, Münster's Original der Cl. serpentina.
9a—9c. Wie oben.

Taf. XVIII. Fig. 1. Clymenia striata Münst., typische Form.
1a—1c. Wie oben.
" 2. Dieselbe, Münster's var. costellata.
2a. 2b. Wie oben.
" 3. Dieselbe, Münster's var. plana.
3a. 3b. Seitenansicht und Sutur.
" 4. Dieselbe, Münster's Original der Cl. dorsocostata.
4a—4c. Wie oben.
4d. Oberflächenzeichnung.

Taf. XVIII. Fig. 5. Dieselbe, typische Form mit tiefen Einschnürungen am Steinkern.
5a. 5b. Wie oben.
" 6. Dieselbe, Münster's var. compressa.'
6a—6c. Wie oben.
" 7. Dieselbe, Münster's var. umbilicata.
7a—7d. Wie oben.
" 8. Dieselbe, ein Fragment mit Runzelschicht und Kiel.
" 9. Dieselbe, var. ornata, Münster's Original der Cl. ornata.
9a—9d. Wie oben.
9e. Die Oberflächenverzierung, stark vergrössert.
" 10. Dieselbe, var. ornata, ein zweites Exemplar mit abweichender Rippenbildung.
10a—10c. Wie oben.
" 11. Clymenia annula Münst., Münster's Original zu seiner Cl. binodosa, var. nodosa.
11a—11d. Wie oben.
" 12. Clymenia undulata Münst., Münster's Cl. bisulcata.
12a—12d. Wie oben.

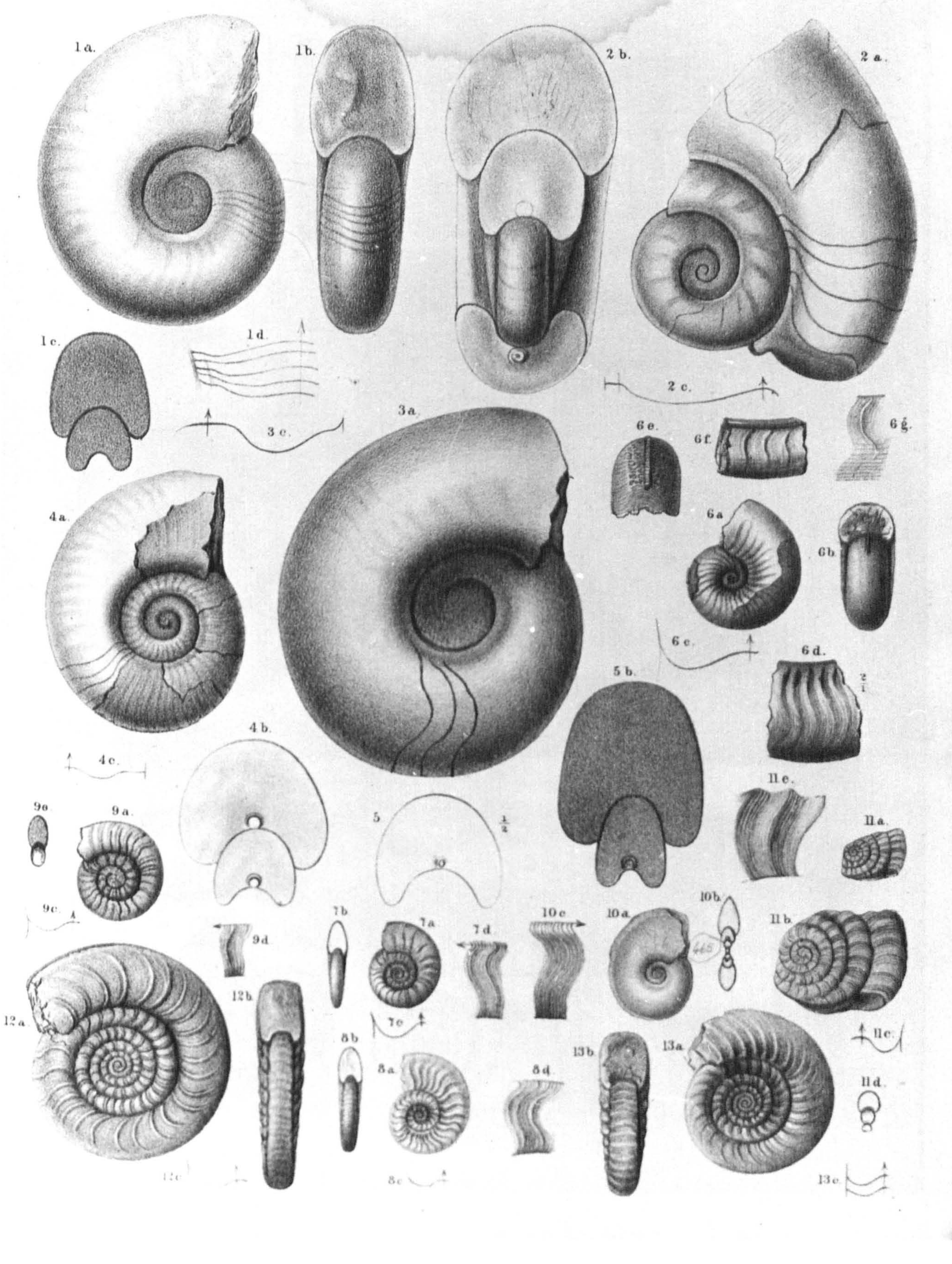
Taf. XIX. Fig. 1. Clymenia binodosa Münst., Münster's Original.
1a—1d. Wie oben.
1e. Die Siphonal-Duten in einem Durchschnitte.
" 2. Clymenia angulosa Münst., Münter's Original.
2a—2c. Wie oben.
2d. Querschnitt.
2e. Siphonal-Röhre im Durchsch.
" 3. Dieselbe, Münster's Original der Cl. semicostata.
3a—3c. Wie oben.
" 4. Clymenia bilobata Münst., Münster's Original.
4a—4c. Wie oben.

Taf. XIX. Fig. 5. Dieselbe, ein kleines Exemplar.
5ᵃ—5ᶜ Wie oben.
„ 6. Clymenia speciosa Münst. spec., typische Form.
6ᵃ—6ᶜ Wie oben, die Suturen bei i mit dem Siphonal-Lobus.
6ᵈ Querschnitt.
„ 7. Dieselbe, Münster's Original zu Goniatites Presli.
7ᵃ—7ᶜ Wie oben.
„ 8. Dieselbe, Münster's Original zu Goniatites Cottai.
8ᵃ—8ᶜ Wie oben.
8ᵈ Oberflächenstreif., vergrössert.

Taf. XX. Fig. 1. Clymenia speciosa, Münster's Original des Goniatites subcarinatus.
1ᵃ 1ᵇ Wie oben.
1ᶜ Querschnitt.
1ᵈ—1ᶠ Sutur in der zweiten, dritten und vierten Windung.
„ 2ᵃ 2ᵇ Querschnitt und Sutur derselben Art in Form des Goniatites clymeniaeformis Münst.
„ 3ᵃ Siphonal-Duten der Clymenia speciosa, bei x mit einer besonders gefärbten Verdichtung.
3ᵇ Dieselben, angeschliffen, den röhrenförmigen Zusammenschluss zeigend.
„ 4. Dieselbe Art, Münster's Original zu Goniatites canalifer mit der Runzelschicht.
„ 5ᵃ 5ᵇ Querschnitt und Sutur der Clymenia Beaumonti Münst.

Taf. XXI. Fig. 1. Clymenia subarmata Münst., Münster's Original zu Goniatites subarmatus.
1ᵃ Seitenansicht.
1ᵇ Stirnansicht.
1ᶜ 1ᵈ Suturen, erstere in der zweiten, letztere in der dritten Windung.
1ᵉ Querschnitt.
„ 2. Dieselbe, ein jugendliches Exemplar, Herrn Prof. Braun gehörig.
2ᵃ Seitenansicht.
2ᵇ Durchschnitt.
2ᶜ Sutur.
„ 3. Clymenia intermedia Münst. spec. Münster's Original.
3ᵃ Seitenansicht, in halber Grösse.
3ᵇ Querschnitt.
3ᶜ—3ᵉ Suturen in der ersten, zweiten und dritten Windung.
„ 4. Dieselbe, Münster's Original zu Goniatites maximus Münst.
4ᵃ Querschnitt in halber Grösse.
4ᵇ Sutur in halber Grösse.
„ 5. Clymenia Haueri Münst. spec.
5ᵃ 5ᵇ Seiten- und Stirnansicht.
5ᶜ Sutur.
5ᵈ Querschnitt.
„ 6. Clymenia planorbiformis Münst.
6ᵃ 6ᵇ Wie oben.
6ᶜ Querschnitt.
6ᵈ 6ᵉ Suturen.
6ᶠ Oberflächenstreifung, vergrössert.

Gümbel 1863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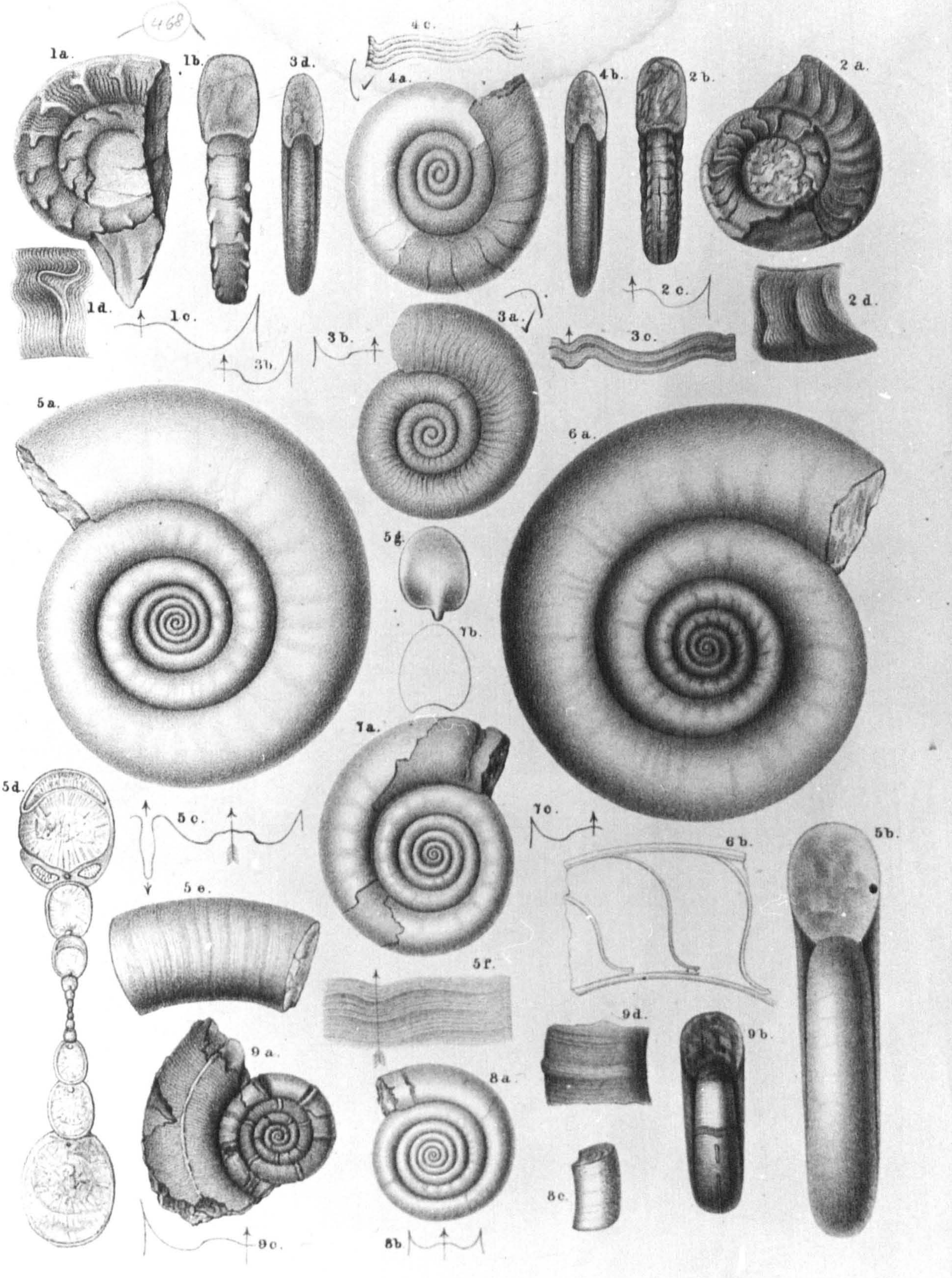
Gümbel 1863



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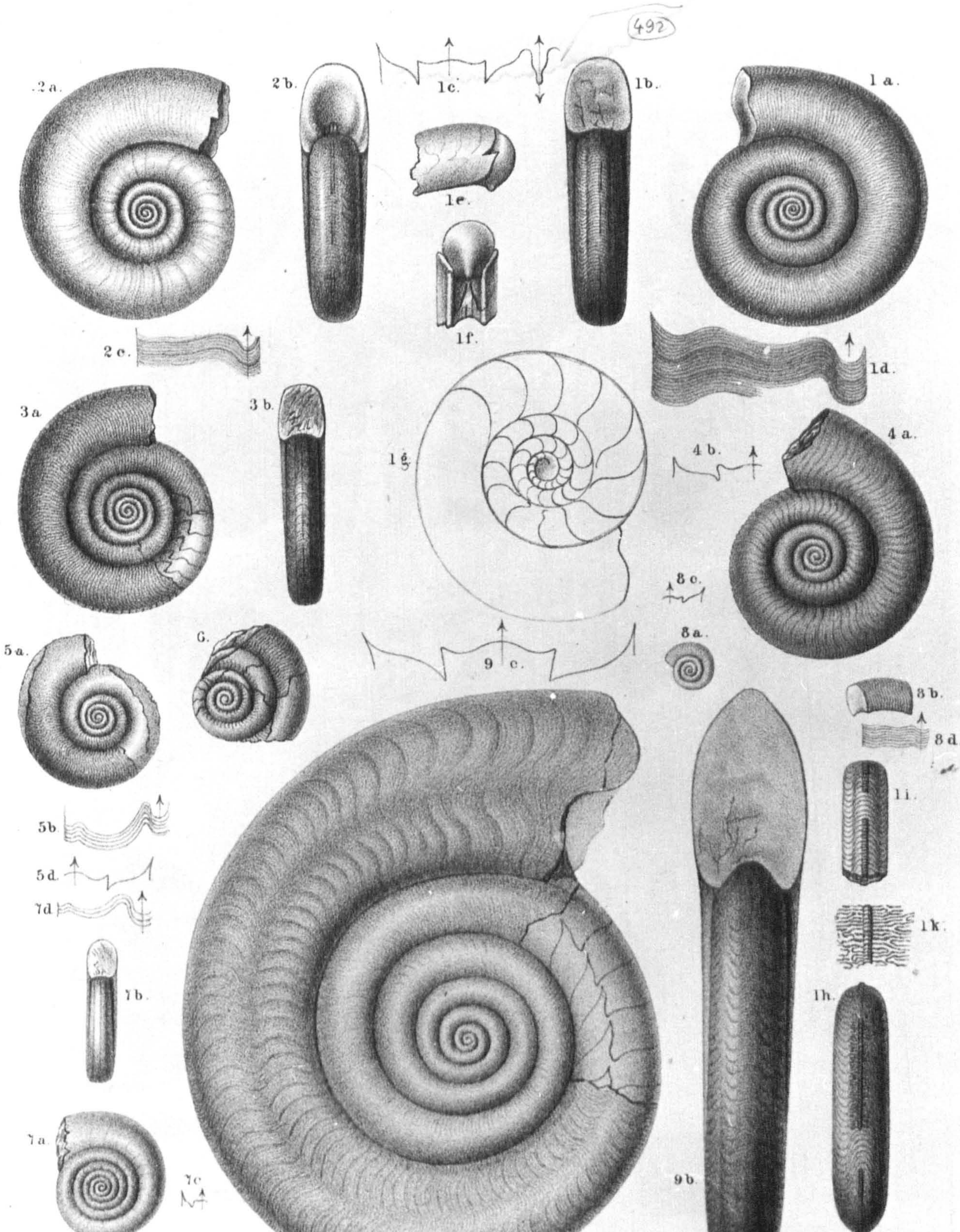
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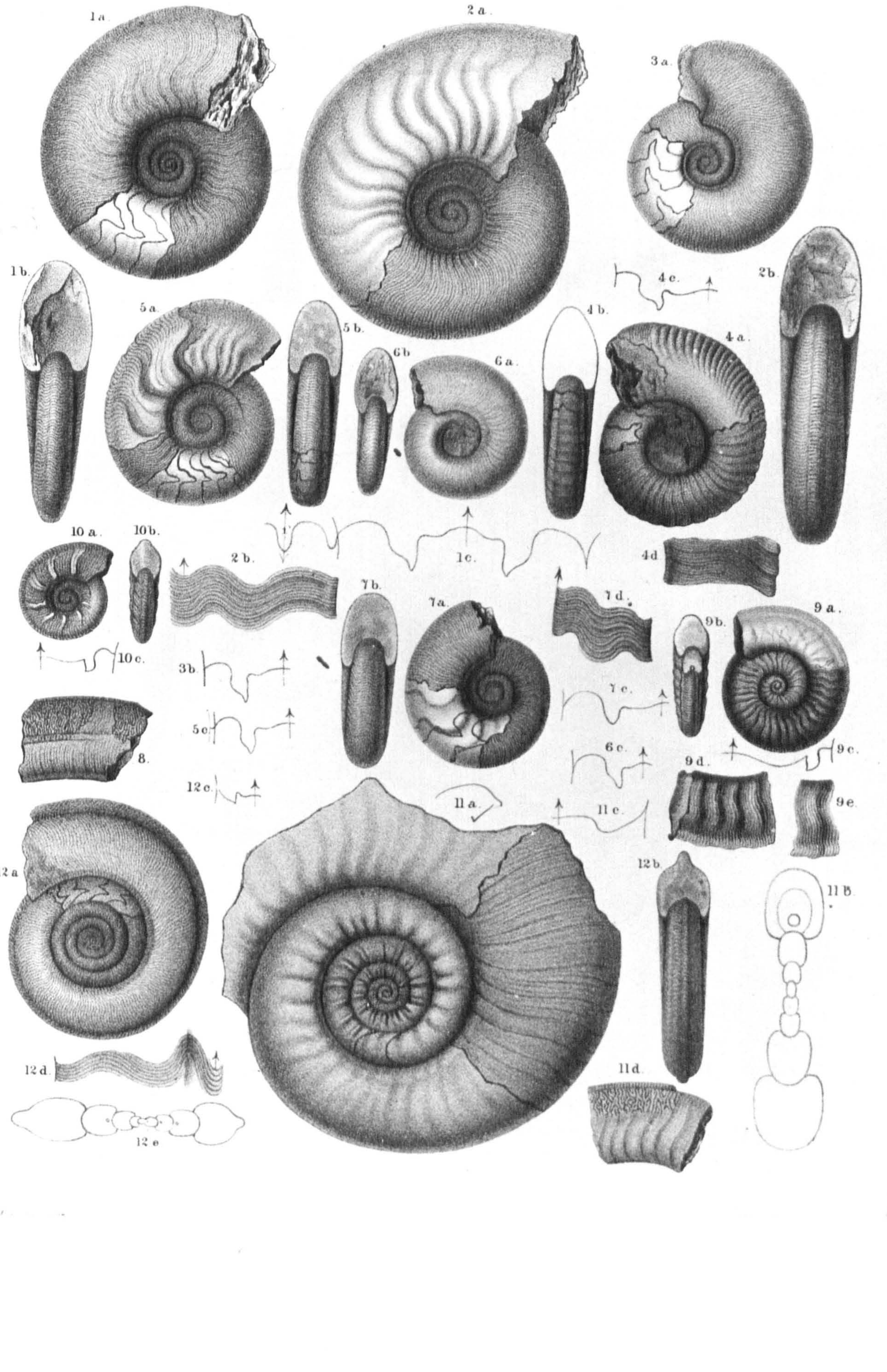
Gümbel gez.

Gümbel 1863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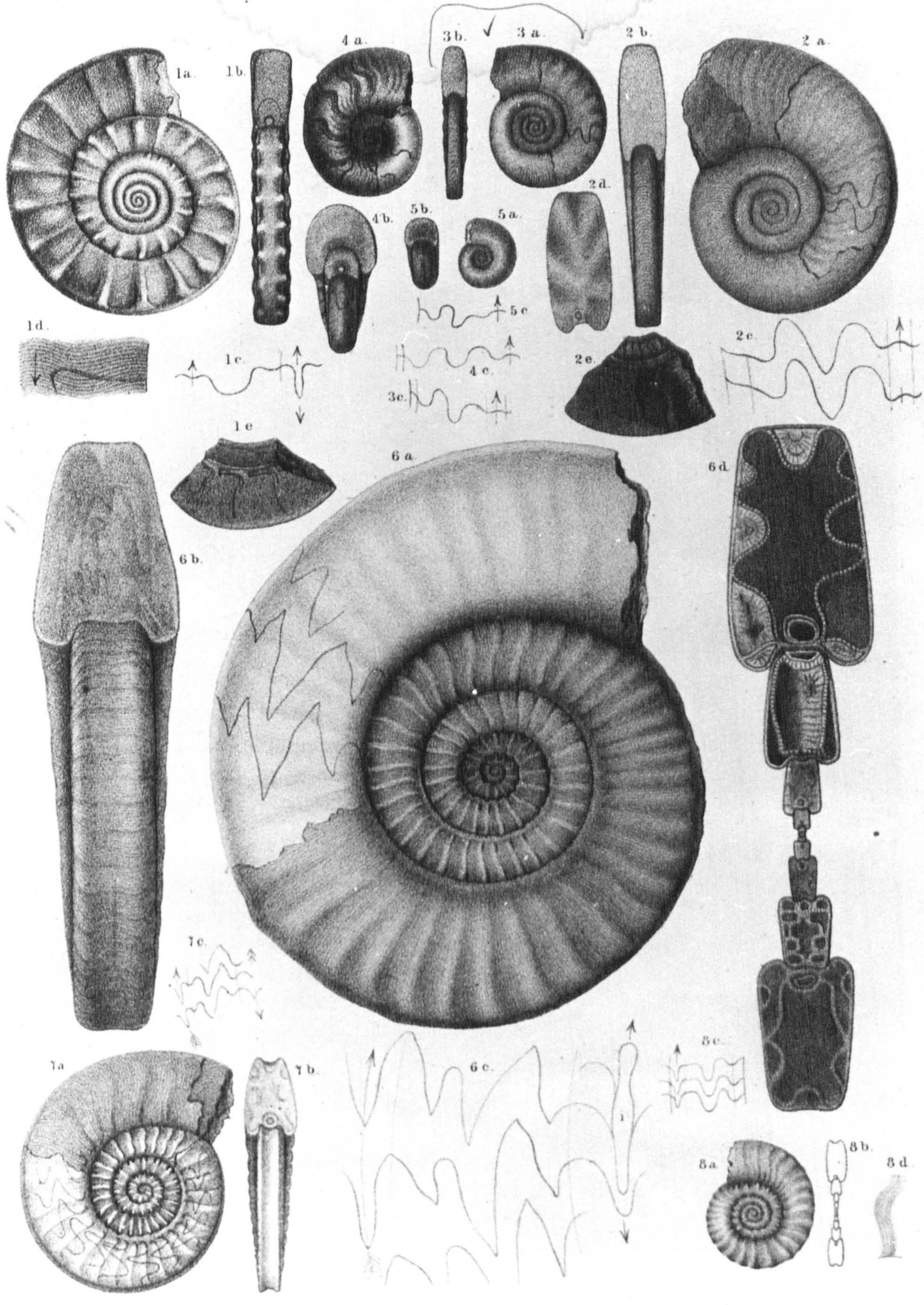
Gümbel 1863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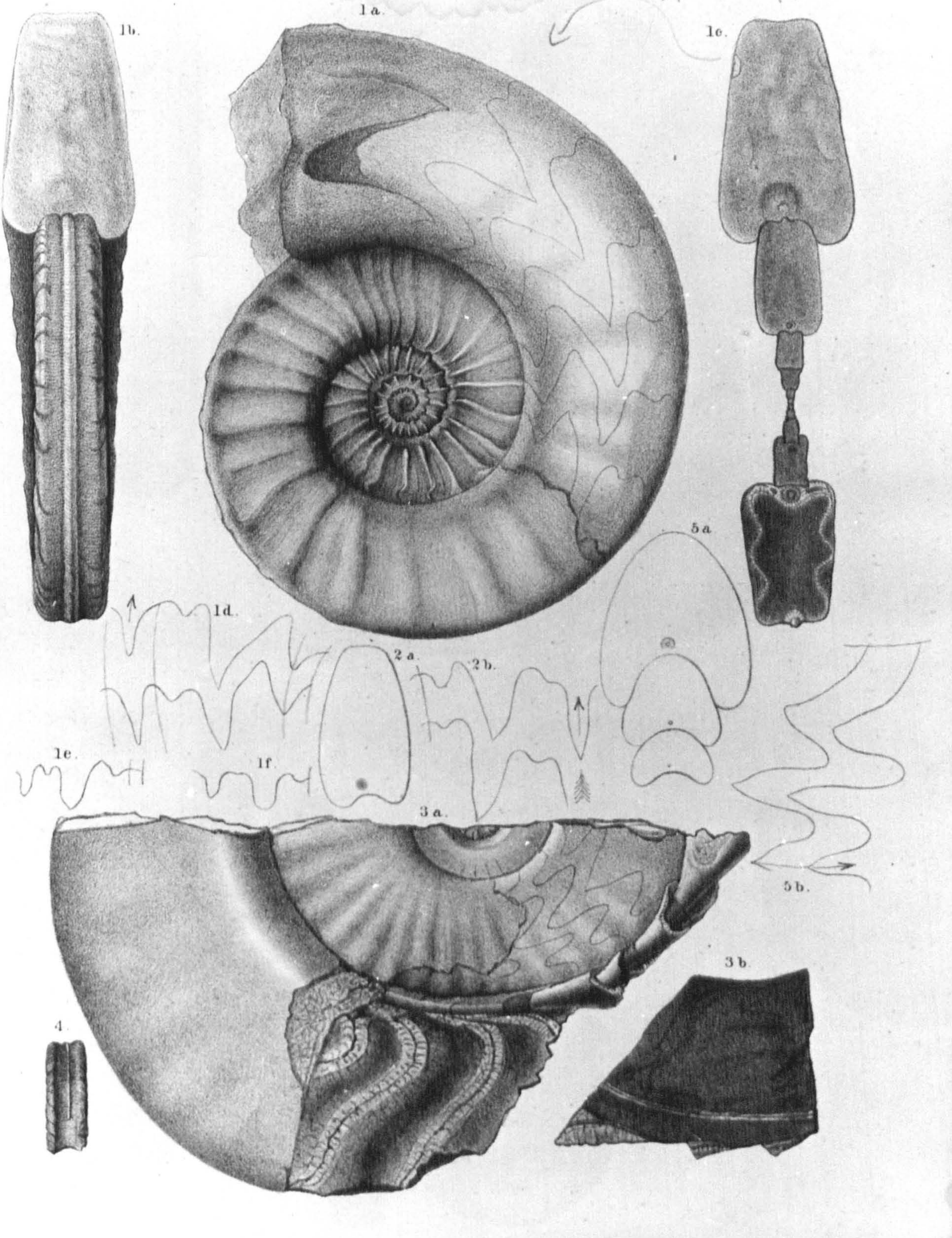
Gümbel 1863

not based on this specimen unless v. idealistic.



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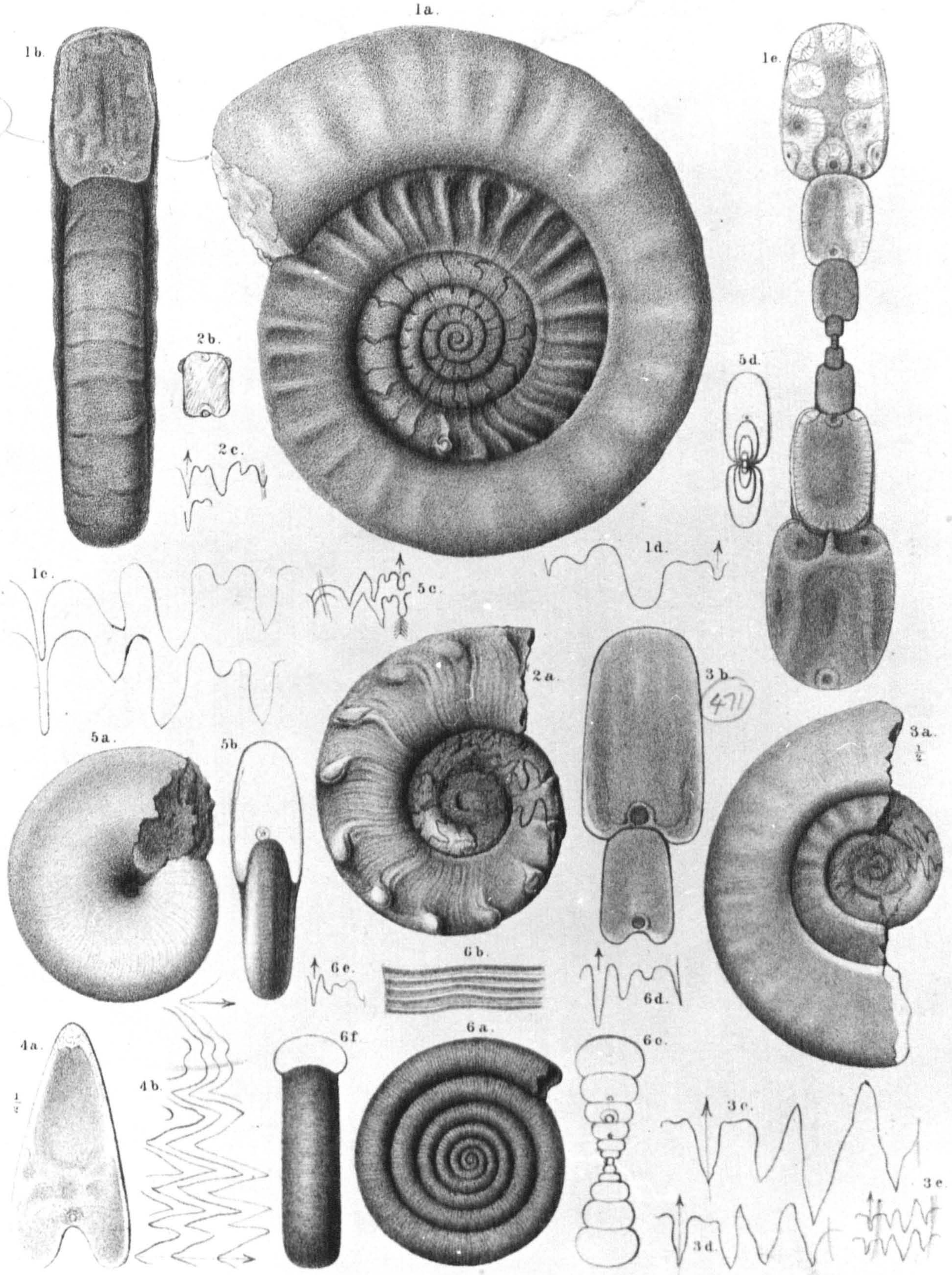

Gümbel, gez.

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Textfig 7.9
Beil
Quarry H
Outcrop A
B1
Outcrop C1
C2
Outcrop J
Outcrop D
Trench E
heavily weathered grey-white nodular limestone exposed by trenching
prominent bedding surface
nodular shale at base
M velifer Zone
M velifer Zone
L velifer Zone Prol. delphinus
U marginifera Zone
see Ziegler 1962, p.154
pompeckji Zone
Sp. (Sp.) biferum
Sp. (Sp.) aff biferum
sandbergeri Zone
Ps. dillensis
Gen. Nov. aff Dimeroceras
? Parat. lentiforme
curvispina Zone
prominent ledge
prominent yellow painted bedding surface
red paint
79/65 cf Gen Nov. D
gy-black shale
red-purple lst
Annulata Shale
Plat. (Trig.) spinosa
24°E/228
? gap
U marginifera Zone
L marginifera Zone
rhomboidea Zone
U crepida Zone
M crepida Zone
? Parat. umbilicatum
? Fault
section measured by Galley and Beese in November 1977
Schäfer 1978
Stratigraphic sequence
See Textfig. 7.2b and 7.10 for locality maps.
See Textfig. 7.11 for faunal range chart.