Annales de la Société géologique de Belgique, T. 115 - fasc. 2 - 1992, pp. 581-593 Juin 1993

THE AMMONOID FAUNAL CHANGE NEAR THE DEVONIAN-CARBONIFEROUS BOUNDARY

by

Dieter KORN[1]

(13 figures)

ABSTRACT.- The Upper Famennian ammonoid fauna is characterized by the predominance of the clymeniids, which became extinct in the topmost Devonian. The Hangenberg Black Shale marks the incision of ammonoid diversity. Survivors are only *Mimimitoceras, Wocklumeria, Lissoclymenia* and *Cymaclymenia,* which in two sections (Müssenberg, Drewer) occur in beds above the Hangenberg Blach Shale together with species of *Acutimitoceras* in the *prorsum* Zone. The *Gattendorfia* Stufe fauna evolved rapidly after the extinction of the clymeniids. The new taxa *Globimitoceras* gen. nov., *Nicimitoceras* gen. nov., and *Mimimitoceras hoennense* sp. nov. are proposed.

INTRODUCTION

The bioevent near the D-C boundary is an important one in the evolution of organisms. The ammonoids in particular show a decline in the topmost Devonian and then a rapid evolution in the lowermost Carboniferous. They are excellent objects to study because they are comparatively abundant on both sides of the boundary and are morphologically diverse.

The D-C boundary was for a long time characterized by the entry of *Gattendorfia subinvoluta*, but is now defined by the first appearance of *Siphonodella sulcata* (2nd meeting of the IUGS D-C boundary working group, Washington, 1979). This agreement caused some difficulties in the correlation of the ammonoid and conodont zonations which had been established, for the most part, in different localities. It was commonly supposed that the new D-C boundary with *S. sulcata* as its index is situated somewhat below the old one defined by *G. subinvoluta* (see Bless *et al.,* 1988; Becker, 1988, etc.).

This assumption is based mainly on the fact that *Protognathodus kuehni* has been used as a valuable substitute index fossil for *Siphonodella sulcata* (Ziegler & Sandberg, 1984; Clausen *et al.,* 1989). If this is accepted, the *Acutimitoceras* fauna (*prorsum* Zone) of several outcrops (Stockum, Müssenberg, etc.) would fall into the Carboniferous. But simultaneous collections of both ammonoids and conodonts show that *P. kuehni* in some sections precedes *S. sulcata* (Clausen *et al.,* 1989, 1990; Schönlaub *et al.,* 1992). Also *S. sulcata* has not been found in the same horizons as the *Acutimitoceras* fauna; consequently, the latter has to be regarded as Devonian according to the current definition of the base of the Carboniferous system.

Many D-C boundary sections have been intensively examined over the last ten years. They can be subdivided in terms of the distribution of the ammonoids. This detailed ammonoid zonations consists of four zones within the *Clymenia* Stufe (Korn, 1981), five zones within the *Wocklumeria* Stufe (Korn, 1986), and four zones within the *Gattendorfia* Stufe (Vöhringer, 1960). This zonation can be applied also in other regions. As shown in Figure 11, many of these zones can be subdivided even further, though, at the moment, this is only possible in the fossiliferous sections of the Rhenish Massif. Ammonoid-bearing sections in other regions essentially verify the stratigraphical scheme, although many sections of North America and China cannot be correlated in detail.

1. *Institut und Museum für Geologie und Paläontologie, Sigwartstrasse 10, D-7400 Tübingen.*

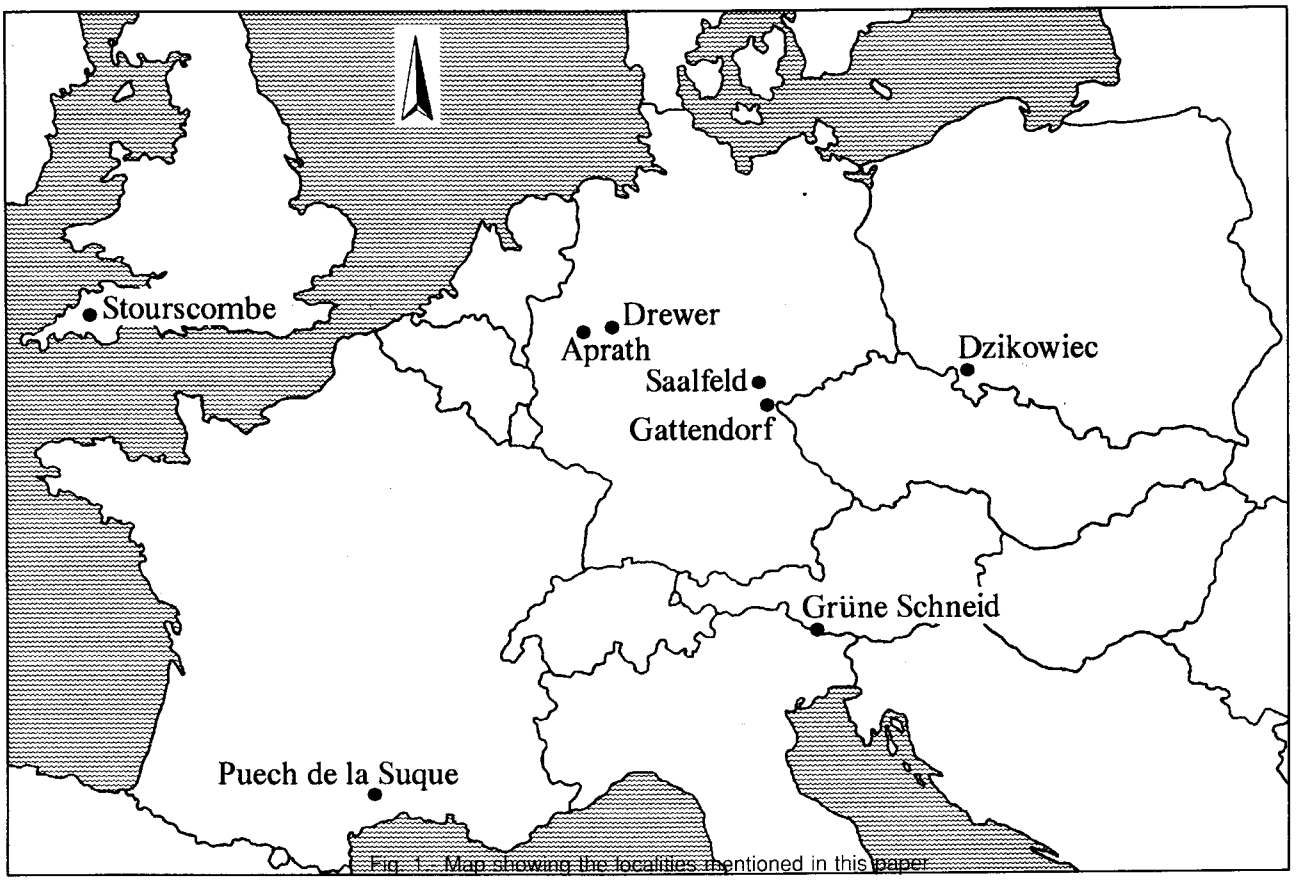

Fig. 1 - Map showing the localities mentioned in this paper.

THE AMMONOID STRATIGRAPHY NEAR THE D-C BOUNDARY

The base of the *Wocklumeria* Stufe has been defined in terms of the entry of the genus *Kalloclymenia* (see Schindewolf, 1937). This interpretation cannot, however, be used because *Kalloclymenia* occurs with typical forms in the upper *Clymenia* Stufe (Price & Korn, 1989). Since a modification of the *Wocklumeria* Stufe range is not reasonable, Price & Korn took *Sphenoclymenia brevispina* as the index fossil for the base of the *Wocklumeria* Stufe. This decision permits the original range definition to be retained. The subdivision of the *Wocklumeria* Stufe given by Schindewolf can be adopted with a few modifications obtained by examining other localities in the neighbourhood of the Ober-Rödinghausen section.

The lower part of the *Wocklumeria* Stufe which does not contain *Wocklumeria* and *Parawocklumeria* was not subdivided by Schindewolf, but can be split into a lower part (= Lower *subarmata* Zone) without and a higher part (= Upper *subarmata* Zone) with *Muessenbiaergia bisulcata* as its index (Korn & Luppold, 1987) [*Kalloclymenia subarmata* itself is no longer used as an index for defining a zone]. The Upper *subarmata* Zone is not a uniform timespan - the genera *Balvia* and *Glatziella* appear in the upper portion of it and suggest a finer subdivision. Hence, in the Rhenish Massif it is possible to subdivide the Upper *subarmata* Zone.

The upper part of the *Wocklumeria* Stufe is characterized by rapid ammonoid evolution. Several distinct ammonoid horizons can be separated : the Lower *paradoxa* Zone (whose base is defined in terms of the first entry of *Parawocklumeria paprothae*) consists of a lower part with *Parawocklumeria paprothae* and species belonging to *Kamptoclymenia,* and an upper part with *Parawocklumeria paradoxa.* Perhaps such a subdivision can be documented also in other regions, such as Carnic Alps.

The Upper *paradoxa* Zone begins with the appearance of *Wocklumeria sphaeroides.* This zone has three different horizons : a lower one with *Postglatziella carinata* but without *Epiwocklumeria applanata;* the middle one containing the maximum frequency of *Wocklumeria sphaeroides* and characterized by *E. applanata;* and the upper part is distinguished by the abrupt facies change to the Hangenberg Black Shale that contains just a few ammonoids. Only two species of *Cymaclymenia,* and one of *Mimimitoceras?* are present (Korn, 1991). Of these species, *C. evoluta* can already be found in clastic intercalations between the Wocklum Limestone (Korn, 1988); *C. nigra* has only been reported from

the black shale; and *M. ? substriatum* is too poorly known and anyway cannot be assigned to distinct stratigraphic levels [most specimens of Vöhringer, 1960, etc. which are regarded as *substriatum,* in fact belong the *Acutimitoceras kleinerae*].

Finally, the top of the *Wocklumeria* Stufe, which is the top of the Upper Devonian, is marked by the *Acutimitoceras* fauna (*prorsum* Zone), when accepting the conodont D-C boundary. With a few exceptions (four clymeniids), the fauna consist only of different *Acutimitoceras* species. None of the typical goniatites from the *Gattendorfia* Stufe, such as *Gattendorfia* and *Eocanites* are yet present.

Another nomenclature for the *Wocklumeria* Stufe subdivision was proposed by Becker (1988), using the terms *subarmata-brevispina* Zone, *endogona* Zone, and *sphaeroides* Zone. The main argument for adopting the traditional Schindewolf (1937) names was that "the zonal definitions remain unchanged" (Becker 1988 : 199). But this statement is incorrect because Schindewolf defined the top of his *sphaeroides* Subzone by the first entry of *Gattendorfia, Eocanites* etc. - the range of the *sphaeroides* Subzone is therefore much longer than that of the *sphaeroides* Zone in Becker's sense.

Also, Becker used two more stratigraphic units; firstly the *evoluta* Zone with *Cymaclymenia evoluta* as its index, and secondly the *evoluta-prorsum*-Interregnum. Both are unnecessary since *Cymaclymenia evoluta* is distributed more widely than previously assumed (Korn, 1988) and is probably restricted to clastic sediments. Thus the *evoluta* Zone proposed by Becker is not a definable timespan; or if one uses the zonal name only for the Hangenberg Black Shale, it would be an eventstratigraphic but not a biostratigraphic unit. An *evoluta-prorsum*-interregnum does not exist because the *Acutimitoceras* fauna occurs immediately above the Hangenberg Black Shale, as can be demonstrated in the Drewer section (Korn, 1991). *Cymaclymenia evoluta* and species of *Acutimitoceras* also occur together.

Becker (1988) also distinguished a Stockum level (which he correlated with the *sulcata* Zone) and the *prorsum* Zone below it, which was held to contain less advanced species of *Acutimitoceras.* Again, such a subdivision is not necessary because all the known occurrences of the *Acutimitoceras* fauna are rather similar in composition, differences being mainly due to the number of specimens available.

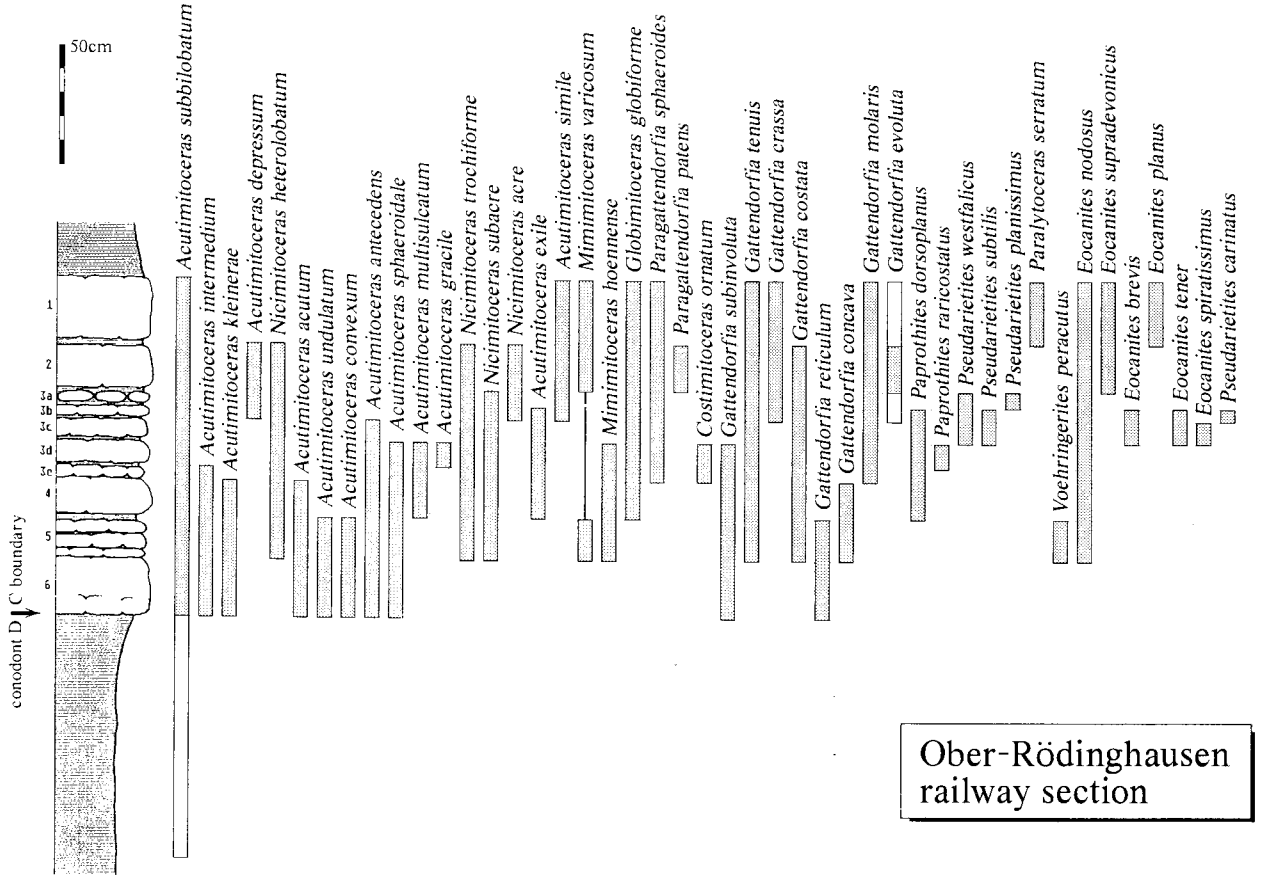

Fig. 2.- The ammonoid distribution in the Hangenberg Limestone at Ober-Rödinghausen railway section (Rhenish Massif, Germany). Data mainly from Vöhringer, 1960.

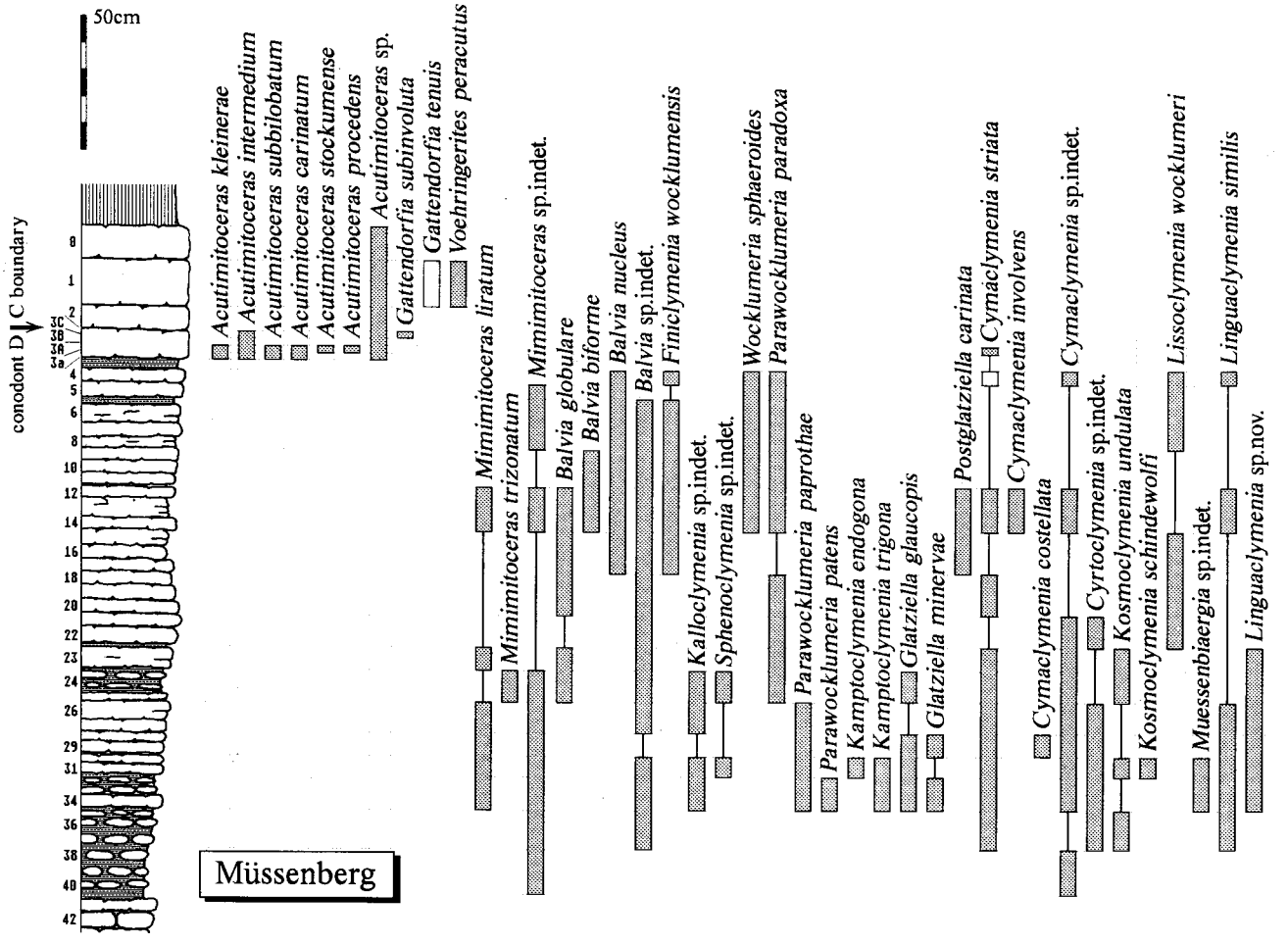

Fig. 3.- The ammonoid distribution in the D-C boundary beds at Müssenberg (Rhenish Massif, Germany)

The subdivision of the *Gattendorfia* Stufe (beginning with the first entry of *Gattendorfia subinvoluta*) proposed by Vöhringer (1960) is still accepted. However, his subzones are now regarded as zones. The zonation embracing the *acutum* Zone, *dorsoplanus* Zone, *westfalicus* Zone, and *patens* Zone from the bottom to the top can be recognized in other regions such as Lower Silesia (Weyer, 1965) and Thuringia (Bartzsch & Weyer, 1982). It is not clear whether the four zones can be subdivided more finely as the range chart of the ammonoids given by Vöhringer suggests; apart from the Ober-Rödinghausen section, there are no rich ammonoid assemblages available for study that were collected on a bed by bed basis.

THE D-C BOUNDARY AMMONOID FAUNA CHANGE

The clymeniids have their evolutionary peak in the Upper *subarmata* Zone and the Lower *paradoxa* Zone (Korn, 1986). More than 15 genera are present here with a high number of different species. Of particular interest are the genera *Kamptoclymenia, Solilymenia* and *Glatziella,* which are restricted to this timespan. Some other genera appear, such as *Parawocklumeria* and *Lissoclymenia,* whereas some longer ranging genera, like *Kosmoclymenia, Cymaclymenia, Cyrtoclymenia* etc. are already present in older deposits.

The faunal spectrum of the Upper *paradoxa* Zone is significantly reduced. Many of the short-ranging genera from the beds below do not exist within it, while *Postglatziella, Finiclymenia, Wocklumeria* and related forms such as *Epiwocklumeria* are typical. Some long ranging genera besides these are still present. Most species from this zone are smoothly ornamented.

Only three clymeniid genera survived the facies change from carbonate to black shale sedimentation. Two almost smooth shelled species of *Cymaclymenia* are known from the Hangenberg Black Shale, and the species *Cymaclymenia striata, Lissoclymenia wocklumeri* and *Wocklumeria sphaeroides* are still present in the *prorsum* Zone, immediately before the order Clymeniida became extinct.

The significance of the goniatites in the Upper Famennian is much less than that of the clymeniids. Beside long-ranging forms like the sporadoceratids and tornoceratids, there are especially the prionoceratids which produced many new taxa (Korn, in press).

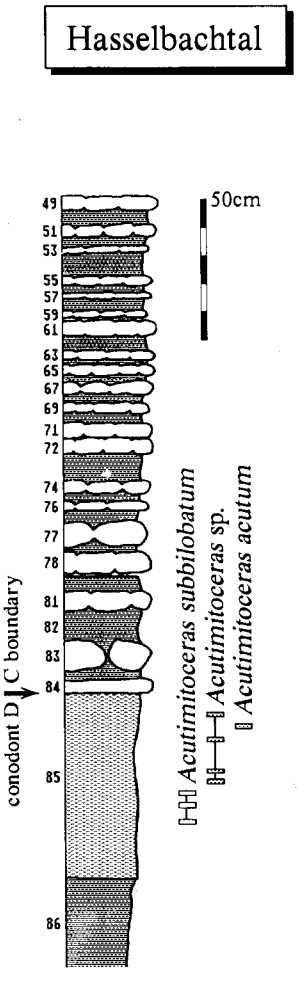

Fig. 4.- The ammonoid distribution of the D-C boundary beds at Hasselbachtal (Rhenish Massif, Germany).

One of these is the genus *Balvia* that evolved from *Mimimitoceras* in the lower part of the *Wocklumeria* Stufe. Species of this genus are very common and typical from the Upper *subarma* Zone to the Upper *paradoxa* Zone, but it appears that *Balvia* did not survive the Hangenberg Event.

According to present knowledge, *Mimimitoceras* was the single goniatite genus to survive the Hangenberg Event. Similar species of this genus are present in the Wocklum and in the Hangenberg Limestone, but typical specimens have not, as yet, been collected from the Hangenberg Black Shale and the Stockum Limestone. It is not sure that the species *substriatum,* found at Schübelhammer and Drewer (at this locality in black nodules within the Hangenberg Black Shale) in fact belongs to *Mimimitoceras* since the early ontogeny in still unknown. Perhaps it belongs to the descendant genus *Acutimitoceras* that evolved rapidly in the *prorsum* Zone into several species. It is notable that an accumulation of *Acutimitoceras* individuals is present in many Middle Europaean D-C boundary sections. The evolution of the genera *Gattendorfia, Eocanites, Paprothites, Pseudarietites* etc. happened after some delay in the *Gattendorfia* Stufe and forms the basis of its subdivision.

The new genus *Globimitoceras* (type species is *Imitoceras globiforme* Vöhringer, 1960) is introduced for involute imitoceratids without constrictions. *Nimitoceras* gen. nov. (type species is *Imitoceras subacre* Vöhringer, 1960) is erected for species with a very small external lobe and a much deeper adventive lobe. Ornament and conch form resemble *Acutimitoceras*. *Sulcimitoceras* Kuzina 1985 is regarded as a subgenus of *Acutimitoceras* .

Also newly erected is the species *Mimimitoceras hoennense* sp. n. (= *Imitoceras liratum liratum* of Vöhringer 1960, p. 125). The holotype is the specimen GPI Tübingen Ce 1130/18.

THE AMMONOID D-C BOUNDARY SUCCESSION IN VARIOUS REGIONS

1.- RHENISH MASSIF

Since the classical examination of the Wocklum Limestone ammonoid fauna by Schindewolf (1937) and of the Hangenberg Limestone by Vöhringer (1960), some progress could be made by concentrating on the beds in between these two cephalopod limestones (Alberti *et al.*, 1971; Clausen *et al.,* 1987, 1989, 1990; Groos-Uffenorde & Uffenorde, 1974; Higgs & Streel, 1984; Korn, 1981, 1984, 1988, 1990, 1991; Korn &Thomas, 1988; Luppold *et al.,* 1984; Ziegler *et al.,* 1988). Rich ammonoid faunas from the Stockum horizon have been collected from Stockum itself as well as from some other localities of the Remscheid-Altena Anticline (at Hasselbachtal and Ober-Rödinghausen from shales; at Drewer and Müssenberg from the base of the Hangenberg Limestone) and of the Herzkamp Syncline (Aprath).

The standard succession of the D-C boundary beds from the base to the top consists of :

- Wocklum Limestone (Lower *subarmata* Zone to middle part of the Upper *paradoxa* Zone). In basin sections it can be replaced partially or completely by shales. All the known occurrences from the top of the Wocklum Limestone yielded the same ammonoid faunas, with *Wocklumeria sphaeroides, Parawocklumeria paradoxa, Finiclymenia wocklumensis, Lissoclymenia wocklumeri* predominating. These beds contain a Middle *praesulcata* Zone conodont fauna which is more evidence for the isochroneity of this horizon.

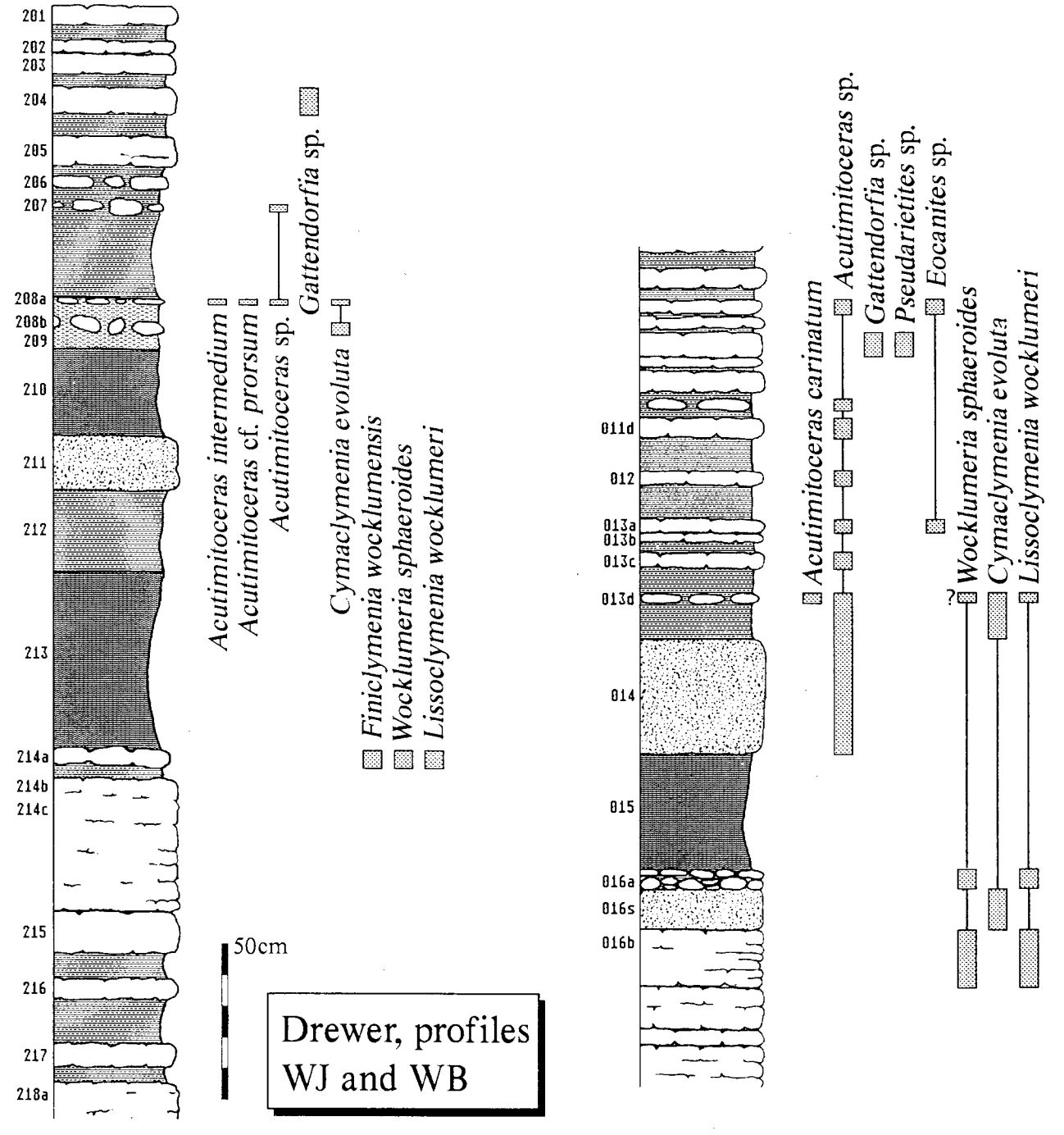

Fig. 5.- The ammonoid distribution in the D-C boundary beds at Drewer, profiles WJ and WB (Rhenish Massif, Germany). Data of profile WB after collections by K. Bartzsch, D. Korn and D. Weyer.

- Hangenberg Black Shale (upper part of the Upper *paradoxa* Zone). In all the sections (of both shoals and basin), this member starts contemporaneously and forms an important index horizon. The ammonoid fauna is composed of only three species (Korn, 1991). Only a few localities (all situated on anticlines) are known in which this horizon is lacking (Hangenberg, Effenberg, Müssenberg).

- Hangenberg Sandstone/Hangenberg Shale. This member formed by turbidity currents is not present in all the sections - laterally the sandstones can disappear and reappear very quickly or can be replaced by siltstones or shales. Ammonoid faunas are rare and have only been collected at Drewer. The crushed specimens belong to the genus *Acutimitoceras* and suggest that this horizon belongs to the *prorsum* Zone.

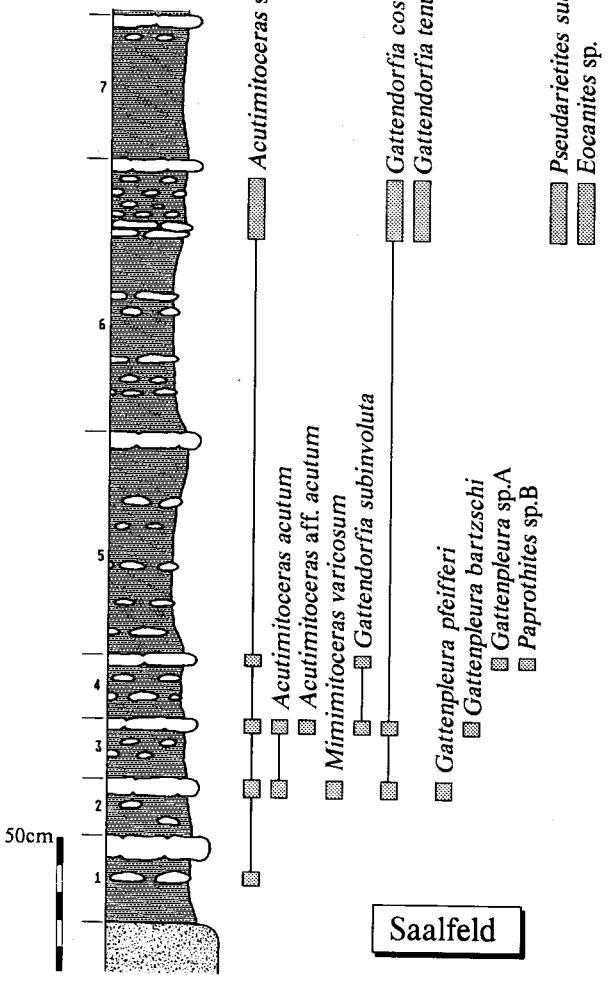

Fig. 6.- The ammonoid distribution in the D-C boundary beds at Saalfeld (Thüringia, Germany). Data from Bartzsch & Weyer, 1982.

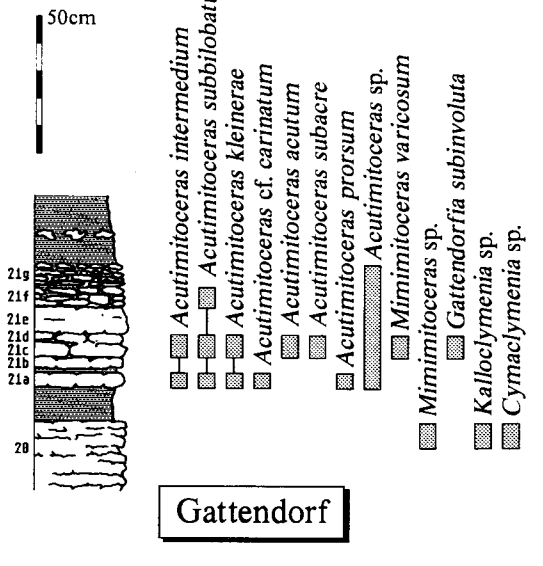

Fig. 7.- The ammonoid distribution in the D-C boundary beds at Gattendorf (Franconia, Germany)

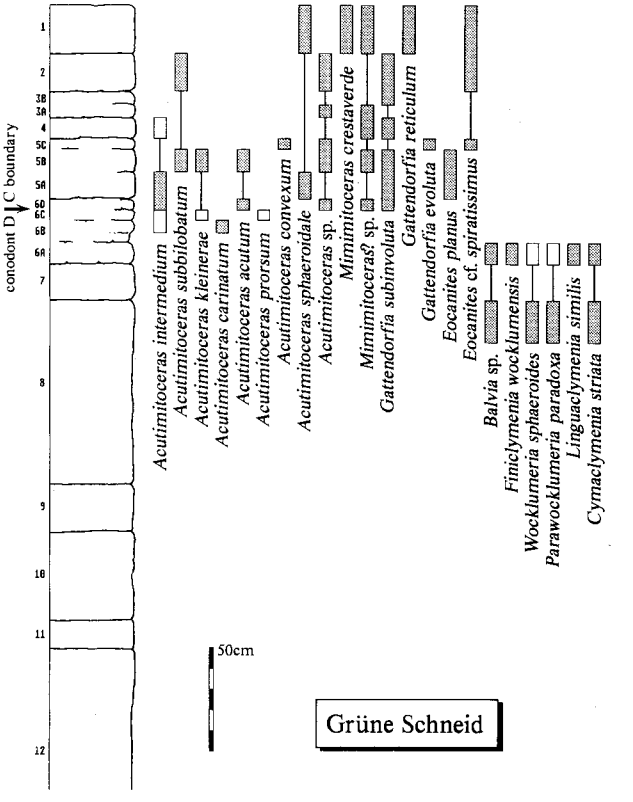

Fig. 8.- The ammonoid distribution in the D-C boundary beds at Grüne Schneid (Carnic Alps, Austria)

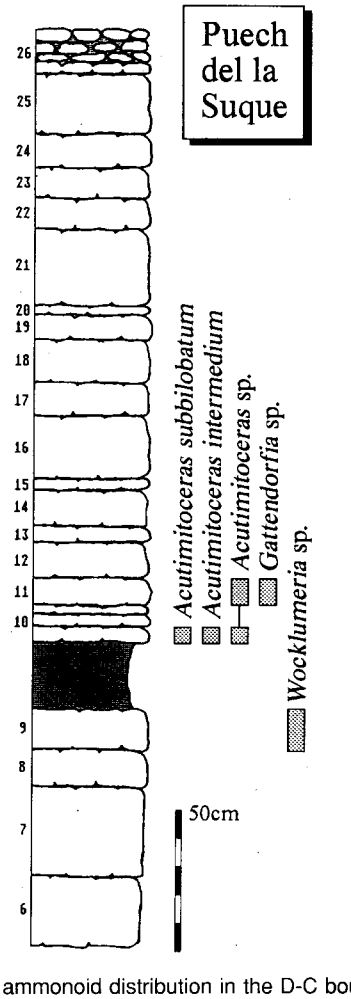

Fig. 9.- The ammonoid distribution in the D-C boundary beds at Puech de la Suque (Montagne Noire, France)

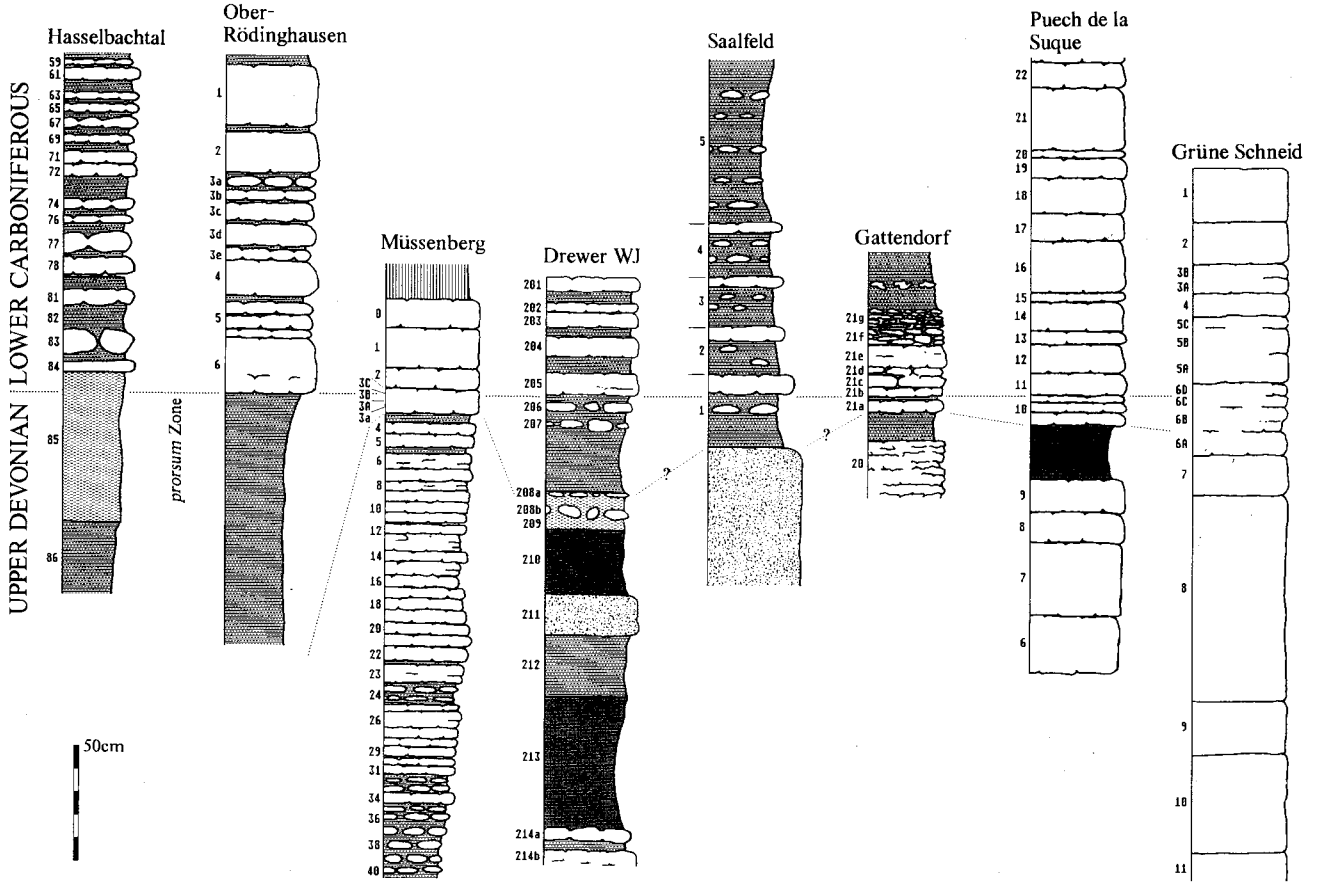

Fig. 10.- Ammonoid based correlation of the eight D-C boundary sections figured in this paper

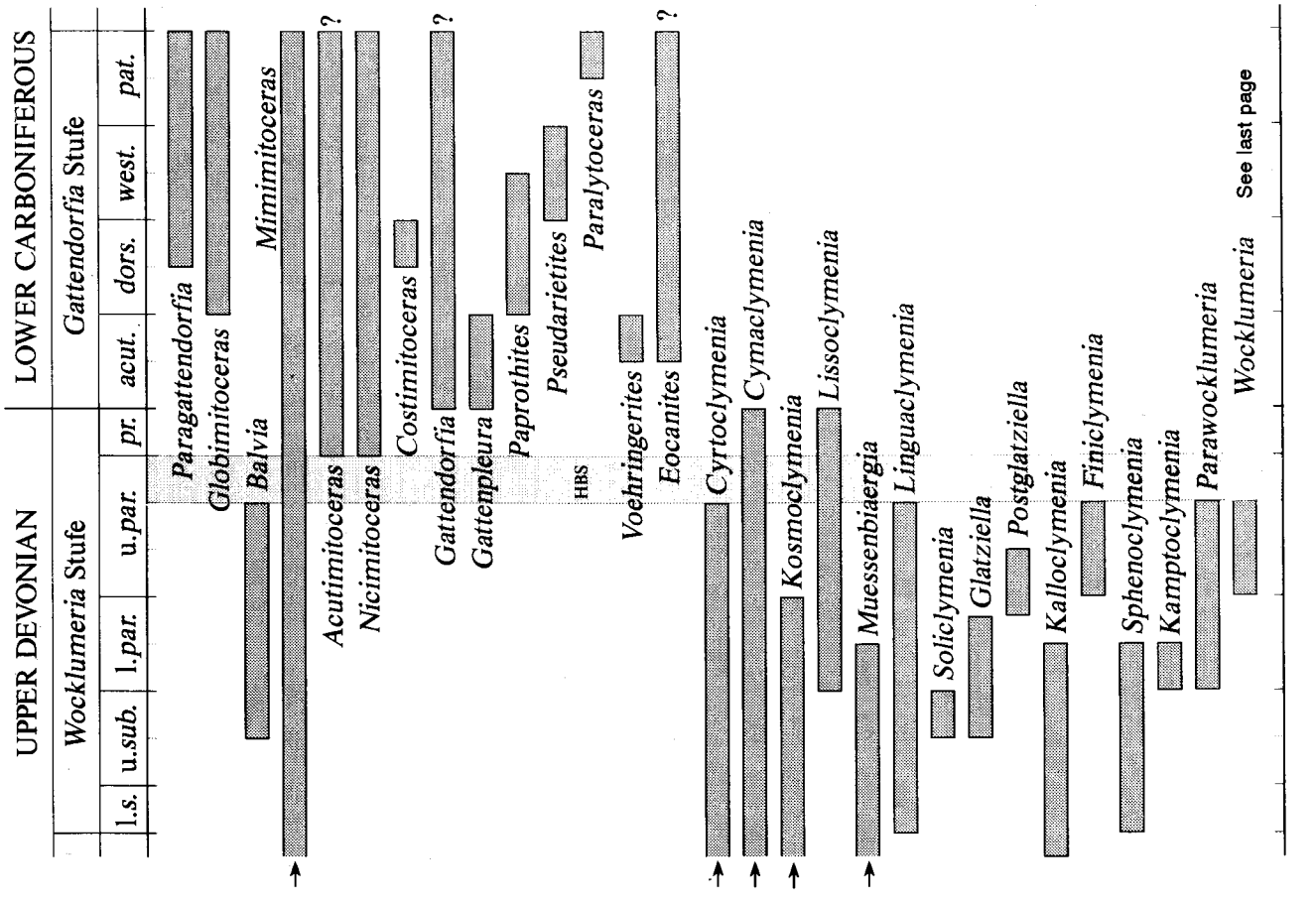

Fig. 11.- Range chart of the prionoceratid and most important clymeniid genera in the uppermost Devonian and lowermost Carboniferous.

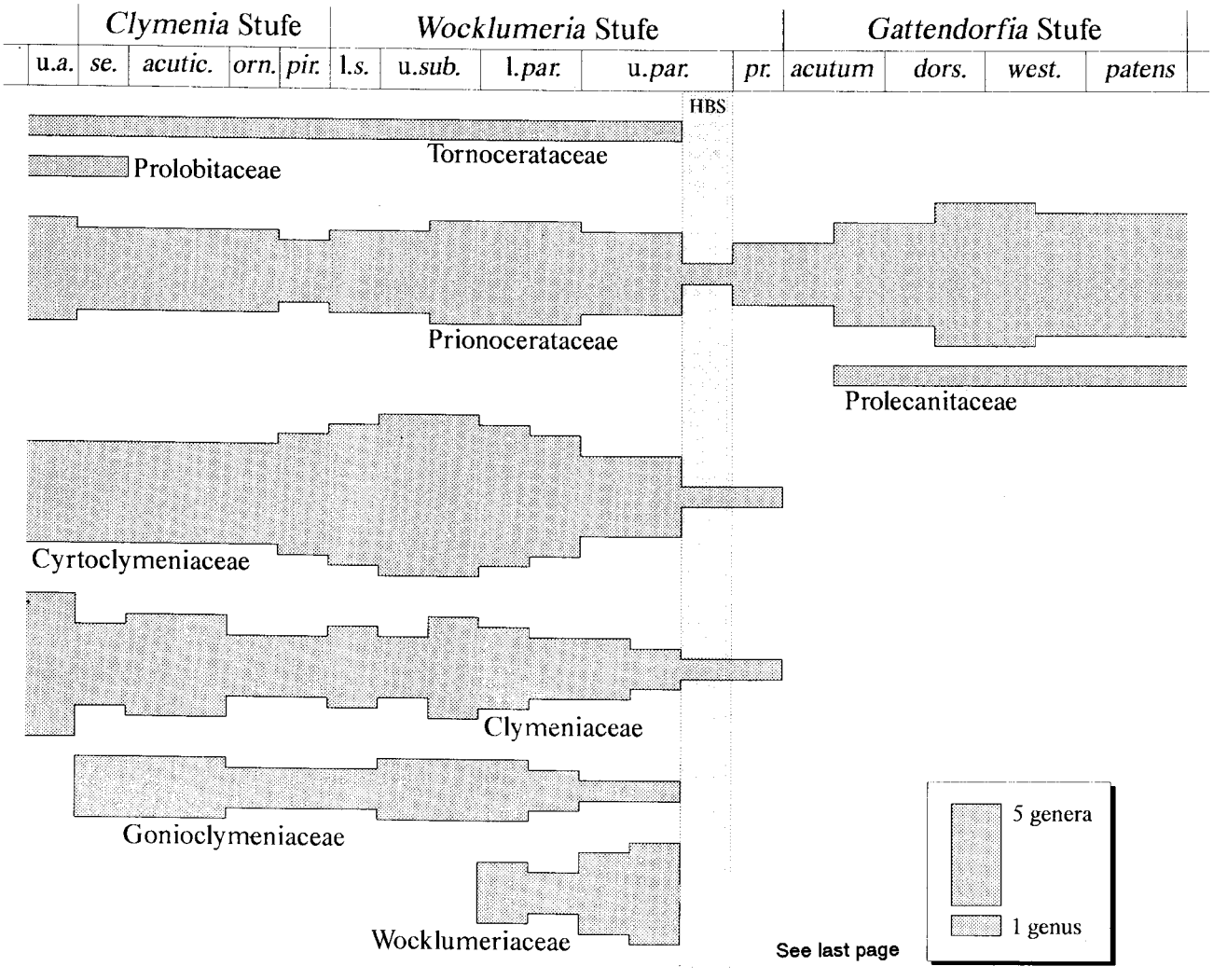

Fig. 12.- Diversification of ammonoid genera from the *Clymenia* Stufe to the *Gattendorfia* Stufe.
Note the acme of diversity in the middle part of the *Wocklumeria* Stufe and the incision during the Hangenberg Black Shale timespan.

- Stockum Limestone (*prorsum* Zone). The typical goniatite-bearing lenses are known only from Stockum where they are situated in between beds of the Hangenberg Sandstone. At Drewer section WJ (Fig. 5) a thin layer of black detritic nodules containing *Acutimitoceras* species is known (Korn, 1991) which resembles the Stockum lenses.

- Hangenberg Limestone (*prorsum* Zone to *patens* Zone) : The heterochronous base of the Hangenberg Limestone can be substantiated by the ammonoid and the conodont faunas. While in the "normal" sections like Drewer (Fig. 5), Müssenberg (Fig. 3), and Effenberg carbonate sedimentation started in the *prorsum* Zone (or alternatively Upper *praesulcata* Zone), the sections more to the west - such as Ober-Rödinghausen (Fig. 2), Hasselbachtal (Fig. 4), show a somewhat later beginning for carbonate sedimentation in the *acutum* Zone (or alternatively *sulcata* Zone) [pace Bless *et al.*, 1988; Becker, 1988]. In the Hasselbachtal section the index goniatite *Acutimitoceras acutum* can be collected below the lowest bed of the Hangenberg limestone.

2.- THURINGIA, FRANCONIA

The sections near Saalfeld (Pfeiffer, 1954; Weyer, 1976; Bartzsch & Weyer, 1982, 1986) basically show the same succession of ammonoid faunas as the Rhenish localities. The lower four zones of the *Wocklumeria* Stufe are very similar, only the Hangenberg Black Shale is missing near Saalfeld. The "Upper Quarzit" is an equivalent of the Hangenberg Sandstone, and a comparable poor *Acutimitoceras* fauna has been collected immediately above the quartzite in the lowest nodules of the uppermost Kalkknollenschiefer. A short distance above this horizon, a typical *Gattendorfia* Stufe fauna has been collected (Fig. 6).

The classical outcrop near Kirchgattendorf has been re-examined from the standpoint of its stratigraphical features (Korn, in prep.). The top of Schindewolf's (1923) bed 20 yielded *Kalloclymenia* sp. and therefore cannot be stratigraphically younger than the Lower *paradoxa* Zone.

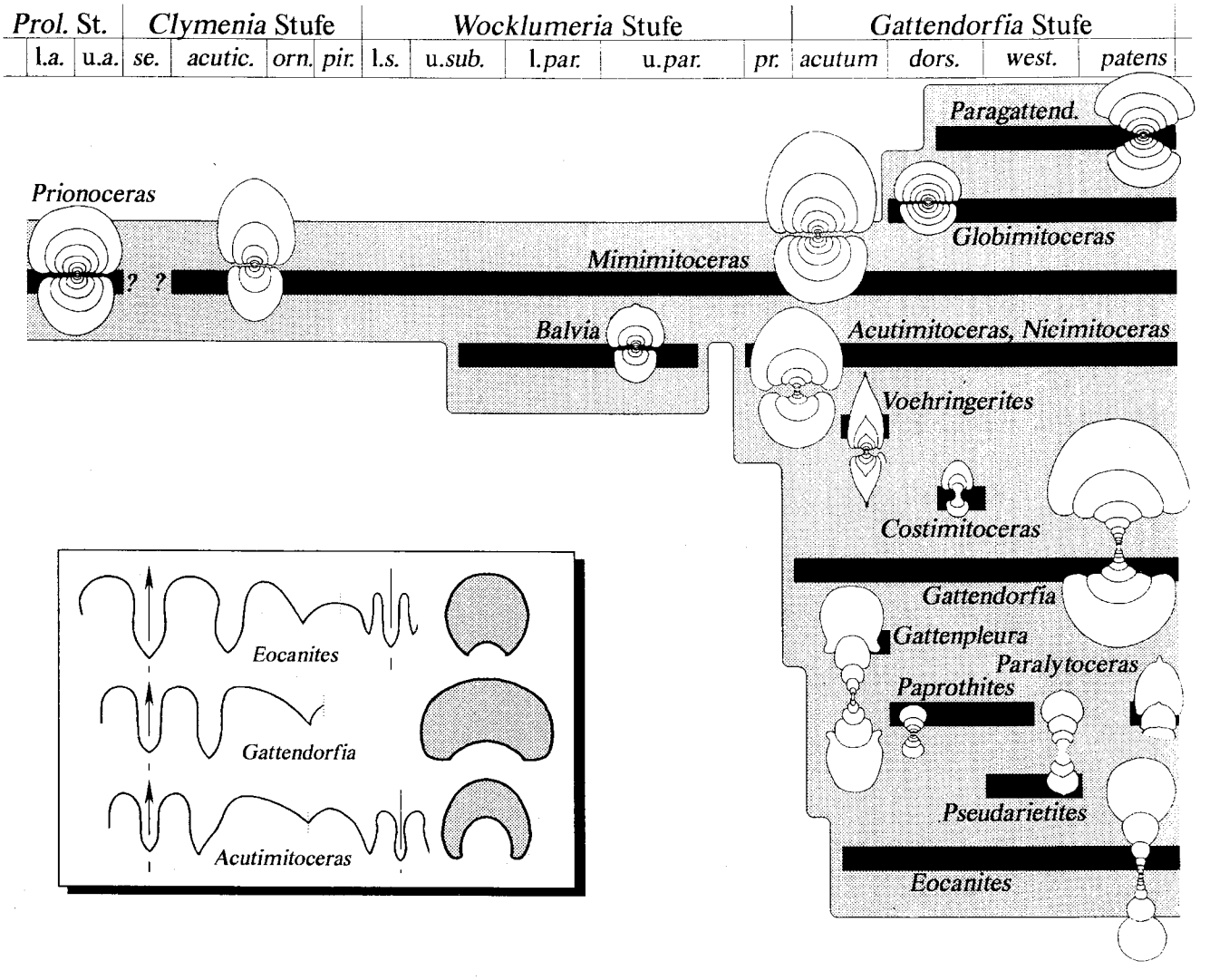

Fig. 13.- Evolution of the prionoceratid and eocanitid ammonoids during the Upper Famennian and lowermost Carboniferous. Note that while the prionoceratid genera in the Upper Famennian only show minor diversification, they rapidly evolved after extinction of the clymeniids. Cross sections mostly after Vöhringer (1960) and Weyer (1977). Also shown is the sutural development from *Acutimitoceras* to *Eocanites*. This shows a continuous migration of the lateral lobe due to evolution of the conch geometry.

Above these nodular limestones a thin clastic bed is intercalated and succeeded by bed 21 (which has been subdivided in six portions, Fig. 7).The lowermost part contains an ammonoid fauna consisting only of *Acutimitoceras* species (*Acutimitoceras kleinerae, Acutimitoceras intermedium, Acutimitoceras prorsum* etc.) and evidently is to be placed in the *prorsum* Zone. *Gattendorfia* appears a little later in higher horizons.

An indication of an *Acutimitoceras* faunal presence is found in the old clymeniid locality at Schübelhammer, immediately above the clymeniid limestones (Korn, in prep.). As at Gattendorf, a gap within the higher part of the *Wocklumeria* Stufe is present that includes the Upper and probably also the Lower *paradoxa* Zone.

3.- LOWER SILESIA

The Dzikowiec section is also characterized by a gap. The youngest Upper Devonian beds belong (with their content of *Parawocklumeria* and *Kamptoclymenia* species) in the Lower *paradoxa* Zone (Schindewolf, 1937; Lewowicki, 1959); the limestones following immediately above this have a higher *Gattendorfia* Stufe age (Weyer, 1965).

4.- CARNIC ALPS

Several D-C boundary sections have been investigated over the last few years. Most ammonoids could be collected from the Grüne Schneid section (Schönlaub *et al.*, 1988, 1992; Korn, 1992).

All the ammonoid zones from the Lower *paradoxa* Zone up to the *acutum* Zone are represented here and are characterized by typical index fossils (Fig. 8). The Hangenberg Black Shale, which is known from the nearby Kronhof Graben section (Schönlaub, 1969), is missing, but may have been replaced by the argillaceous component of bed 6B1. Otherwise the section is completely composed of cephalopod limestones. It is important to note that *Gattendorfia subinvoluta* and *Siphonodella sulcata* enter in the same horizon.

5.- MONTAGNE NOIRE

While the shallow water section at La Serre yielded only a few wocklumeriids from the top of the Upper Devonian (Flajs & Feist, 1988), the other localities show a succession comparable to that in the Rhenish Massif. The sections at the Puech de la Suque (Fig. 9) and Pic de Vissous contain a Hangenberg Black Shale equivalent of 30 to 50 cm thickness that is intercalated in a sequence of cephalopod limestones. Directly below it, specimens of *Wocklumeria* can be collected. Above the shales, an accumulation of *Acutimitoceras* individuals is present, and the section at the Puech de la Suque yielded *Gattendorfia* a short distance above this horizon. Again, *Siphonodella sulcata* is not present in the *Acutimitoceras* horizon (R. Feist, pers. comm.).

6.- CORNWALL

Selwood (1960) described ammonoids from Stourscombe and Yeolmbridge. They belong to the lower four zones of the *Wocklumeria* Stufe as well as the higher part of the *Gattendorfia* Stufe.

7.- MUGODZHARS

The well-known, extremely fossiliferous section at the Kiya river yielded an Upper *paradoxa* Zone ammonoid fauna from the base of bed 11 (Simakov *et al.,* 1985). Ammonoids from higher beds are not known.

Another D-C boundary section is known from Berchogur (Barskov *et al.,* 1984; Kuzina, 1985; Simakov *et al.,* 1985; Bogoslovskiy, 1987, 1988), but ammonoids have only been collected from two horizons which are situated very close to the D-C boundary. This ammonoid fauna is composed mainly of *Acutimitoceras* species and contains no typical forms of the *Gattendorfia* Stufe.

8.- GUIZHOU

Rich ammonoid faunas from the *Wocklumeria* Stufe and also the *Gattendorfia* Stufe have been described by Ruan (1981) from Wangyou. Unfortunately, this material has not been strictly collected bed by bed. There is probably no gap in the succession, however, because all the typical index fossils are present. Beside the Ober-Rödinghausen section, Wangyou yielded the richest ammonoid fauna of the *Gattendorfia* Stufe.

The nearby Muhua and Dapoushang sections (Sheng, 1989), are very interesting in the context of the D-C boundary. They are composed only of limestones with a thin intercalation of clastic material between the Daihua and the Wangyou Formations. The uppermost bed of the Daihua Formation at Dapoushang contains *Parawocklumeria paradoxa* and *Cymaclymenia* sp. and is thought to belong in the Upper *paradoxa* Zone. The conodont fauna of this bed is of Middle *praesulcata* Zone age. The Wangyou Formation above this contains ammonoid faunas of the *Gattendorfia* Stufe in the Dapoushang Member and the Linushan Member, but a correlation with distinct ammonoid zones is still impossible.

9.- GUILIN

The section at Nambiancun (Ruan, 1988) was also a stratotype candidate for the D-C boundary, but yielded only a few ammonoids (especially from the *Wocklumeria* Stufe beds). A subdivision of the section with the ammonoids is still very incomplete.

BIBLIOGRAPHY

ALBERTI, H., GROOS-UFFENORDE, H., STREEL, M., UFFENORDE, H. & WALLISER, O.H., 1974.- The stratigraphical significance of the *Progrnathodus* fauna from Stockum (Devonian-Carboniferous boundary, Rhenish Schiefergebirge). *Newsl. Stratigr.,* 3 : 263-276.

BARSKOV, I.S., SIMAKOV, K.V., ALEKSEEV, A.S., BOGOSLOVSKIY, B.I., BYVSHEVA, T.V., GAGIEV, M.H., KONONOVA, L.N., KOCHETKOVA, N.M., KUZINA, L.F. & REITLINGER, E.A., 1984.- Devonian-Carboniferous transitional deposits of the Berchogur section, Mugodzary, USSR. *Cour. Forsch.-Inst. Senckenberg,* 67 : 207-230.

BARTZSCH, K. & WEYER, D., 1982.- Zur Stratigra phie des Untertournai (*Gattendorfia*-Stufe) von Saalfeld im Thüringischen Schiefergebirge. *Abh. Ber. Naturkd. Vorgesch.,* 12 (4) (for 1981) : 3-54.

BARTZSCH, K. & WEYER, D., 1986.- Biostratigraphie der Devon/Karbon-Grenze im Bohlen-Profil bei Saalfeld (Thüringen, DDR). *Z. geol. Wiss.,* 14 : 147-152.

BECKER, T., 1988.- Ammonoids from the Devonian-Carboniferous Boundary in the Hasselbachtal valley (Northern Rhenish Slate Mountains). *Cour. Forsch.-Inst. Senckenberg,* 100 : 193-213.

BLESS, M.J.M., SIMAKOV, K.V. & STREEL, M., 1988.- Advantages and disadvantages of a conodont-based or event-stratigraphic Devonian-Carboniferous Boundary. *Cour. Forsch.-Inst. Senckenberg,* 100 : 3-14.

BOGOSLOVSKIY, B.I., 1987.- *Ammonoidei. In :* Maslov, V.A. (ed.): Fauna i Biostratigrafiya pogranichn'ych otlozheniy devona i karbona Berchogura (Mugodzhary) : 52-58.

BOGOSLOVSKIY, B.I., 1988.- Evolyutsiya i biokhronologiya ammonoidei na rubezhe Devona i Karbona. *In :* Granitsa Devona i Karbona na territorii SSSR ; 248-254.

CLAUSEN, C.-D., KORN, D., LUPPOLD, F.W. & STOPPEL, D., 1990.- Untersuchungen zur Devon/Karbon-Grenze auf dem Müssenberg (Nördliches Rheinisches Schiefergebirge). *Bull. Soc. belge Géol.,* 98 (3/4) : 353-369.

CLAUSEN, C.-D., LEUTERITZ, K. & ZIEGLER, W., 1987.- The eastern Provincial Quarry at Drewer (northeastern Rhenish Slate Mountains), a stratotype candidate for the Devonian-Carboniferous Boundary. *Senckenbergiana lethaea,* 87 (5/6) : 467-477.

CLAUSEN, C.-D., LEUTERITZ, K. & ZIEGLER, W. (with a contribution of KORN, D.), 1989.- AusgewählteProfile an der Devon/Karbon-Grenze im Sauerland (Rheinisches Schiefergebirge). *Fortschr. Geol. Rheinld. u. Westf.,* 35 : 161-226.

FLAJS, G. & FEIST, R., 1988.- Index conodonts, trilobites and environment of the Devonian-Carboniferous Boundary beds at La Serre (Montagne Noire, France). *Cour. Forsch.-Inst. Senckenberg,* 100 : 53-107.

GROOS-UFFENORDE, H. & UFFENORDE, H., 1974.- Zur Mikrofauna im höchsten Oberdevon und tiefen Unterkarbon im nördlichen Sauerland (Conodonta, Ostracoda, Rheinisches Schiefergebirge). *Notizbl. hess. L.-Amt Bodenforsch.,* 102 : 58-87.

HIGGS, K. & STREEL, M., 1984.- Spore stratigraphy at the Devonian-Carboniferous boundary in the northern "Rheinisches Schiefergebirge", Germany. *Cour. Forsch.-Inst. Senckenberg,* 67 : 157-179.

KORN, D., 1981.- Ein neues, Ammonoideen-führendes Profil an der Devon-Karbon-Grenze im Sauerland (Rhein. Schiefergebirge). *N. Jb. Geol. Paläont. Mh.,* 1981 (9) : 513-526.

KORN, D., 1984.- Die Goniatiten der Stockumer *Imitoceras*-Kalklinsen (Ammonoidea; Devon/Karbon-Grenze). *Cour. Forsch.-Inst. Senckenberg,* 67 : 71-89.

KORN, D., 1986.- Ammonoid evolution in late Famennian and early Tournaisian. *Ann. Soc. géol. Belg.,* Spec. vol. "Aachen 1986", 109 : 49-54.

KORN, D., 1988.- On the stratigraphical occurrence of *Cymaclymenia evoluta* (H. Schmidt, 1924) at the type locality. *Cour. Forsch.-Inst. Senckenberg,* 100 : 215-216.

KORN, D., 1990.- *Cymaclymenia* aus der *Acutimitoceras*-Fauna (*prorsum*-Zone) vom Müsenberg (Devon/Karbon-Grenze; Rheinisches Schiefergebirge). *Bull. Soc. belge Géol.,* 98 (3/4) : 371-372.

KORN, D., 1991.- Threedimensionally preserved clymeniids from the Hangenberg Black Shale of Drewer (Cephalopoda, Ammonoidea; Devonian-Carboniferous boundary; Rhenish Massif). *N. Jb. Geol. Paläont., Mh.,* 1991 (9) : 553-563.

KORN, D., 1992.- Ammonoideen aus dem Oberdevon und Unterkarbon von Aprath, Schurf Steinbergerbach und Strasseneinschnitt Kohleiche. *In :* Thomas, E. (Ed.) : Oberdevon und Unterkarbon von Aprath im Bergischen Land : 169-182.

KORN, D., 1992.- Ammonoideen aus dem Devon/Karbon-Grenzprofil an der Grünen Schneid (Karnische Alpen, Österreich). *Jb. Geol. B.-A.,* 135 (1) : 7-19.

KORN, D., in press.- Heterochony in the evolution of Upper Devonian Ammonoids, Acta Paleont. Polonica.

KORN, D. & LUPPOLD. F.W., 1987.- Nach Clymenien und Conodonten gegliederte Profile des oberen Famennium im Rheinischen Schiefergebirge. *Cour. Forsch.-Inst. Senckenberg,* 92 : 199-223.

KORN, D. & THOMAS, E., 1988.- Ammonoids from the Devonian-Carboniferous boundary of Aprath (Velbert Anticline, Northern Rhenish Massif). *Cour. Forsch.-Inst. Senckenberg,* 100 : 219-220.

KUZINA, L.F., 1985.- K revizii roda *Imitoceras. Zh. Paleont.,* 1985 (3) : 35-48.

LEWOWICKI, S., 1959.- Fauna wapieni Klimeniowych z Dzikowieca Klodzkiego. *Biul. Inst. Geol.,* 146 : 73-118.

LUPPOLD, F.W., HAHN, G. & KORN, D., 1984.- Trilobiten-, Ammonoideen- und Conodonten-Stratigraphie des Devon/Karbon-Grenzprofiles auf dem Müssenberg (Rheinisches Schiefergebirge). *Cour. Forsch.-Inst. Senckenberg,* 67 : 91-121.

PFEIFFER, H., 1954.- Der Bohlen bei Saalfeld/Thüringen. *Geologie, Beih.,* 11 : 1-105.

PRICE, J.D. & KORN, D., 1989.- Stratigraphically important Clymeniids (Ammonoidea) from the Famennian (Late Devonian) of the Rhenish Massif, West Germany. *Cour. Forsch.-Inst. Senckenberg,* 110 : 257-294.

RUAN YIPING, 1981.- Devonian and earliest Carboniferous ammonoids from Guangxi and Guizhou. *Mem. Nanking Inst. Geol. Palaeont., Acad. Sinica,* 15 : 1-139.

RUAN YIPING, 1988.- Ammonoids. *In :* Yu Changmin (ed.): Devonian-Carboniferous boundary in Nanbiancun, Guilin, China. - Aspects and records : 251-262.

SCHINDEWOLF, O.H., 1937.- Zur Stratigraphie und Paläontologie der Wocklumer Schichten (Oberdevon). *Abh. Preuss. geol. L.-Anst.,* N.F. 178 : 1-132.

SCHÖNLAUB, H.P., 1969.- Conodonten aus dem Oberdevon und Unterkarbon des Kronhofgrabens (Karnische Alpen, Österreich). *Jb. Geol. B.-Anst.,* 112 : 321-354.

SCHÖNLAUB, H.P., FEIST, R. & KORN, D., 1988.- The Devonian-Carboniferous Boundary at the section "Grüne Schneid" (Carnic Alps, Austria) : A preliminary report. *Cour. Forsch.-Inst. Senckenberg,* 100 : 149-167.

SCHÖNLAUB, H.P., ATTREP, M., BOECKELMANN, K., DREESEN, R., FEIST, R., FENNINGER, A., HAHN, G., KLEIN, P., KORN, D., KRATZ, R., MAGARITZ, M., ORTH, C.J. & SCHRAMM, J.-M., 1992.- The Devonian-Carboniferous Boundary in the Carnic Alps (Austria) - A multidisciplinary Approach. *Jb. Geol. B.-A.,* 135 (1) : 57-98.

SELWOOD, E.B., 1960.- Ammonoids and trilobites from the Upper Devonian and Lowest Carboniferous of the Launceston Area of Cornwall. *Palaeontology,* 3 (2) : 153-185.

SHENG HUAIBIN, 1989.- Ammonoids. *In :* JI *et al.* (ed.): The Dapoushang section. An excellent section for the Devonian-Carboniferous boundary stratotype in China : 108-119.

SIMAKOV, K.V., ALEKSEEV, A.S., BARSKOV, I.S., BOGOSLOVSKIY, B.I., BYVSHEVA, T.V., GAGIEV, M.Kh., KONONOVA, L.I., KOCHETKOVA, N.M., KUZINA, L.F., KULAGINA, E.I., ONOPRIENKO, Yu.I., PAZYKHIN, V.N., RADKONOVA, E.P., RAZINA, T.P., REITLINGER, E.A., SMIRNOVA, L.V. & YAVBULATOVA, M.G., 1985.- Biostratigrafiya pogranichnykh otlozheniy Devonia i Karbon a Mugodzhar : 1-55.

VÖHRINGER, E., 1960.- Die Goniatiten der unterkarbonischen *Gattendorfia*-Stufe im Hönnetal (Sauerland). *Fortschr. Geol. Rheinld. u. Westf.,* 3/1 : 107-196.

WEYER, D., 1965.- Zur Ammonoideen-Fauna der *Gattendorfia*-Stufe von Dzikowiec (Ebersdorf) in Dolny Slask (Niederschlesien), Polen. *Ber. geol. Ges. DDR,* 10 (1965) : 443-464.

WEYER, D., 1976.- Ein neues Ammonoidea-Genus aus dem Untertournai des Thüringischen Schiefergebirges. *Z. geol. Wiss.,* 6 : 837-857.

ZIEGLER, W., JI QIANG & WANG CHENGYUAN, 1988.- Devonian-Carboniferous Boundary - Final candidates for a stratotype section. *Cour. Forsch.-Inst. Senckenberg,* 100 : 15-19.

ZIEGLER, W. & SANDBERG, C.A., 1984.- Important candidate sections for stratotype of conodont based Devonian-Carboniferous boundary. *Cour. Forsch.-Inst. Senckenberg,* 67 : 231-239.

(figs 11 and 12) : Another field examination, and producing of thin sections give evidence for a channel deposition at the base of bed 013d at Drewer section WB. Therefore, there is a reworked fauna at the base of bed 016d and the *Wocklumeria sphaeroides* specimen is (probably) reworked.