

The stratigraphical significance of the *Protognathodus*
fauna from Stockum (Devonian/Carboniferous boundary,
Rhenish Schiefergebirge)

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with 2 figures



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Summary: The Stockum Limestone is the stratum typicum of the *Imitoceras* fauna described by H. SCHMIDT 1924 and of the *Protognathodus* fauna described by ZIEGLER 1969. New investigations have been made on the fossils from this limestone and from the sequences immediately above and below. *Gattendorfia subinvoluta* was not found in the Stockum Limestone. This species possibly appears immediately after the deposition of the Stockum Limestone. On the other hand it is not possible to distinguish the conodont and trilobite fauna of this limestone from that of the stratum typicum of *Gattendorfia subinvoluta*. Therefore it would be more practicable to include the Stockum Limestone in the Lower Carboniferous. The associated ostracodes and spores also support such a solution. However, for a definitive assignment of stratigraphical position, and for a more precise definition of the Devonian/Carboniferous boundary, we need further detailed studies of the evolutionary development of the important goniatites and conodonts.

Zusammenfassung: Der Stockumer Kalk, stratum typicum der von H. SCHMIDT 1924 beschriebenen *Imitoceras*-Fauna und der von ZIEGLER 1969 veröffentlichten *Protognathodus*-Fauna, sowie die ihn unter- und überlagernden Schichten wurden hinsichtlich ihres Fossilinhaltes neu untersucht. *Gattendorfia subinvoluta* wurde im Stockumer Kalk nicht gefunden. Diese Art setzt eventuell erst unmittelbar nach Ablagerung des Stockumer Kalkes ein. Andererseits ist dessen Conodonten- und Trilobiten-Fauna nicht von der des stratum typicum von *Gattendorfia subinvoluta* zu unterscheiden. Es wäre deshalb praktikabler, den Stockumer Kalk in das Unterkarbon zu stellen. Auch die Ostracoden und Sporen lassen eine solche Einstufung als geeigneter erscheinen. Eine endgültige Festlegung der stratigraphischen Position und damit eine Präzisierung der Grenze Devon/Karbon sollte jedoch erst erfolgen, nachdem die Entwicklung der wichtigen Goniatiten- und Conodonten-Arten subtil erfaßt wurde.

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1. Introduction

Conodont faunas with the genus *Protognathodus* have proved to be important for drawing the boundary between the Devonian and Carboniferous Systems. This has been recognized by BISCHOFF (1957), COLLINSON, SCOTT & REXROAD (1962), and WEYER (1965). A more detailed description by ZIEGLER followed in 1969. His fauna originated from the so-called Stockum Limestone (Stockumer Kalk), south of the "Spitze Kahlenberg" near Stockum, southwest of Arnberg in the Rhenish Schiefergebirge. The sample was cut off the original material from H. SCHMIDT, who in 1924 described the goniatite fauna, composed of several species of the genus *Imitoceras*.

It was mainly the opinion of VÖHRINGER (1960) and WEYER (1965) about the *Imitoceras* fauna as well as the assumed position in the sequence that led ZIEGLER to place the Stockum Limestone into the uppermost Devonian. This seemed to be confirmed by later correlations using spores (STREEL, see section 2.3.5.). On the other hand for H. SCHMIDT & E. RICHTER the trilobites from the Stockum Limestone were unambiguously Lower Carboniferous (see section 2.3.2.).

In order to clarify the stratigraphical position three trenches (see fig. 1) were made at and near the locus typicus under the technical direction of H. ALBERTI. The research on conodonts was done by H. ALBERTI, H. UFFENORDE and O. H. WALLISER, on goniatites by O. H. WALLISER, on ostracodes by H. GROOS-UFFENORDE, on trilobites by H. ALBERTI, on spores by M. STREEL.

Acknowledgements: We are thankful for Mrs. Kleinert's permission to dig the trenches in her property. The Deutsche Forschungsgemeinschaft sponsored the project as a part of the special analysis program of the Sonderforschungsbereich 48 Göttingen. Prof. Dr. D. MEISCHNER made available an additional conodont fauna from the original material of H. SCHMIDT (1924). Dr. W. RIEGEL made some preliminary determinations of spores and discussed the floras with Mrs. Dipl.-Geol. L. ALBERTI contributed to the field work at Stockum and Kirchgattendorf. We received technical aid from H. BECKER, Dipl.-Geol. Th. JUNGHANSS, Miss E. WILGEROTH and Mrs. I. BADURA. For this help and cooperation we are very grateful.

2. Stratigraphical sequence and fossils from the type locality of the Stockum Limestone

2.1. Introduction

Locus typicus: Near the NE-corner of the 1 : 25.000 mapsheet 4713 Plettenberg; 50 m SW of "Spitzer Kahlenberg"; 410 m SE "Stumpfer Kahlenberg"; 10 m above the road in the Schwermecke valley; coordinates: 3430190/5684605.

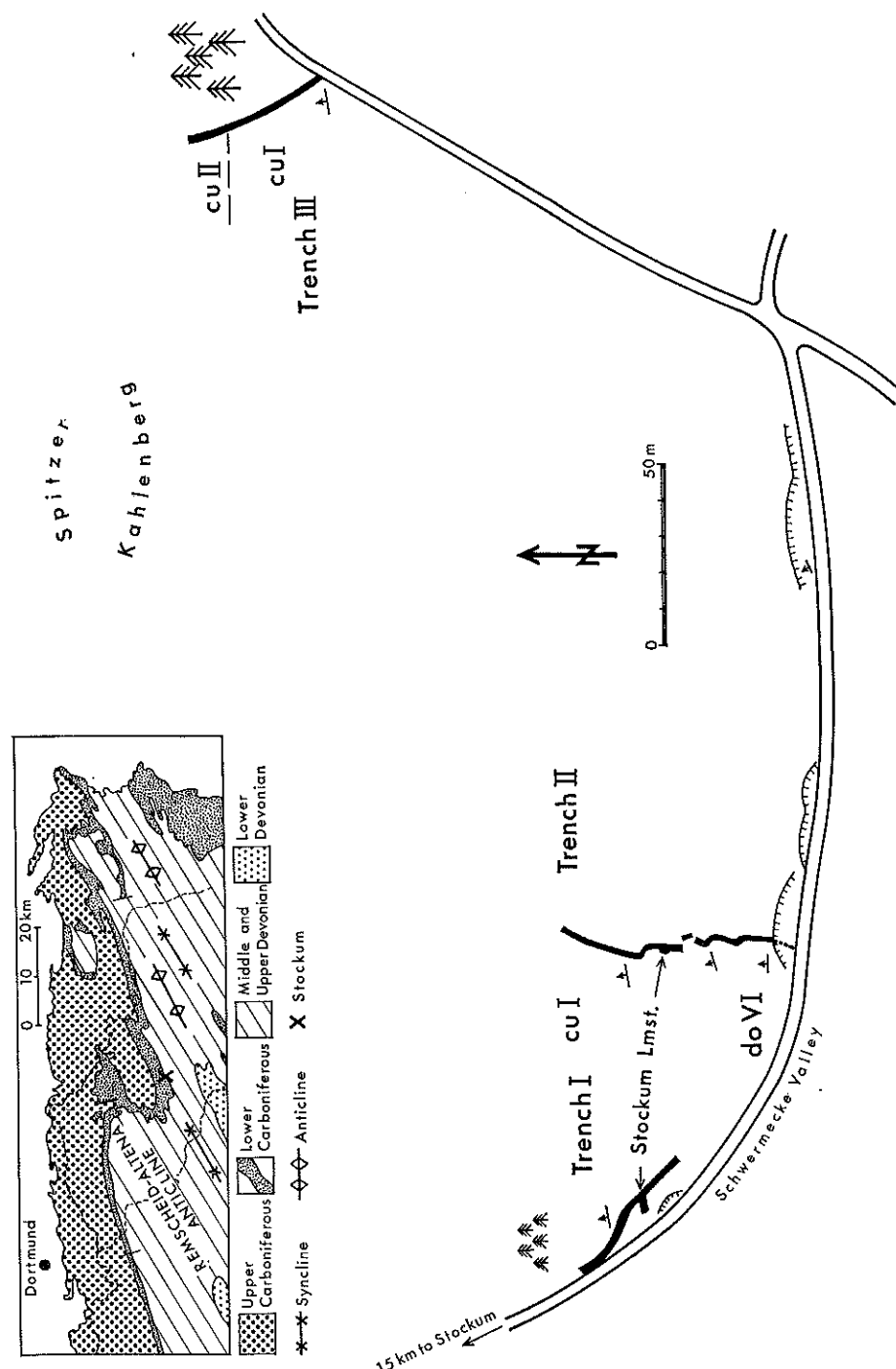


Fig. 1. Position of the trenches through the Upper Devonian — Lower Carboniferous sequences near Stockum.

The *Imitoceras* fauna from Stockum was discovered by the master's candidate CAESAR and then collected by HENKE (HENKE, 1924: 31). After H. SCHMIDT (1924) investigated on the fauna, HENKE as well as H. SCHMIDT (1924) assigned it to the Carboniferous as the lowest member under the name "Etroeungt". HENKE (1924: 31) described the additional strata of this member as "graue Tonschiefer mit Lagen von Toneisensteinen und glimmerhaltigen, z. T. kalkigen Grauwackensandsteinen, in denen Einlagerungen von Oolithen und Geröllen von Quarz und Kalk vorkommen". GALLWITZ published in 1928 a detailed geological map of the type area. A profile, supposedly from the type locality, drawn by E. PAPROTH, was given by ZIEGLER (1969).

With help of the above information and discussion with Prof. H. SCHMIDT the location of trench I was determined. Within this trench the Stockum Limestone was found at the above coordinates.

In trench I only the sequence called Etroeungt by HENKE (see chapter 2.2.) was found.

To see the relation to the overlying and underlying sequences two additional trenches were dug (see fig. 1).

2.2. Sequence

Since a detailed description of the section is not necessary in context of the problems discussed in this article, it will appear in a forth coming paper. Only short explanations of the simplified profiles (see fig. 2) will be given. Roughly, from top to bottom, the sequence can be subdivided as follows (the thicknesses are approximate values, as partly reconstructed from inclination of layers and topography):

- E) 5 m „Liegende Alaunschiefer“, in the upper part with sherty layers
- D) 36 m greyish green, silty shales. In the lower half there are few siltstones and sandstones, mostly calcareous, micaceous and laminated as well as concentrations of carbonate in the shales
- C) 14,5 m greyish green to dark green, mostly silty and partly micaceous shales of variable carbonate content. Intercalated are numerous siltstones and sandstones, partly with high carbonate content, laminated and micaceous
Especially characteristic is the uppermost part:
 - f) 0,60 m calcareous shales with changing silt content
 - e) 0,30 m sandstone with high carbonate content
 - d) 0,20 m shales, partly with silt and mica
 - c) 0,07 m Stockum Limestone (*sensu stricto*)
 - b) 0,40 m silty shales with some layers of more silty, sandy or micaceous composition
 - a) 0,50 m sandstone with high carbonate and mica content
- B) 7 m greyish green, silty shales, with thinly banded layers and changing carbonate content. The content of silt and mica increases gradually in the upper half
- A) Shales with a content of fine silt and intercalated layers of limestone nodules.

In the lithological subdivision at least the members D and C are equivalent to the so-called "Hangenberg-Schichten" (H. SCHMIDT, 1924). A sharp lower boundary cannot be drawn, since the shales of the lower part of the section gradually merge into the member C by gradually increasing silt and mica content.

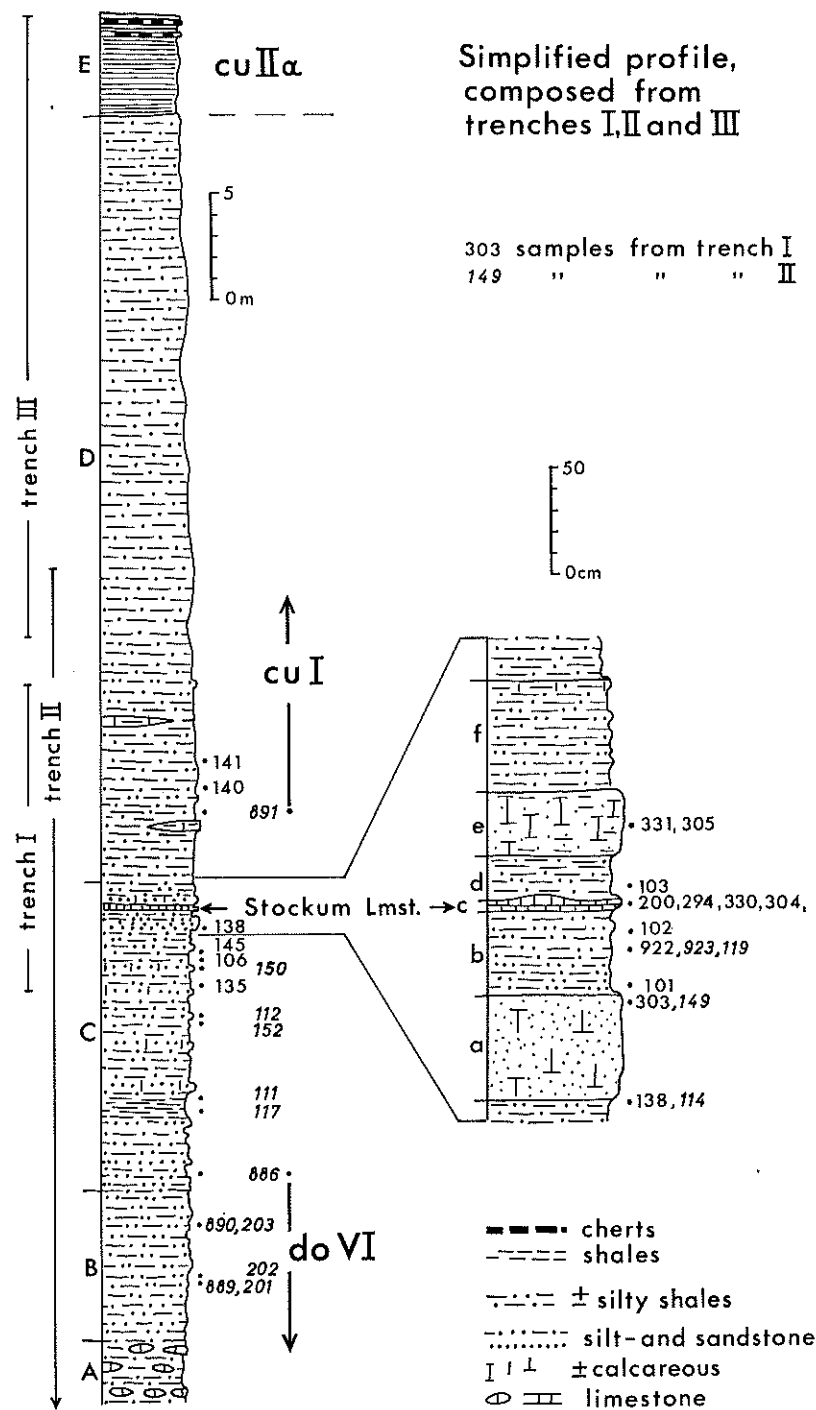


Fig. 2. Simplified profiles through the Upper Devonian — Lower Carboniferous sequences near Stockum.

2.3. Fossils

2.3.1. Goniatites

In 1924 H. SCHMIDT described from the Stockum Limestone several species of goniatites which he referred to the genera *Aganides*, *Gattendorfia* and *Imitoceras*. Corresponding to this determination he correlated the Stockum Limestone with the lower carboniferous so-called Hangenberg Limestone.

In his monograph of the goniatites from the Hangenberg Limestone of the *Gattendorfia* stage from the Höhne valley, VÖHRINGER (1960: 188) mentioned that according to the species of *Imitoceras*, the Stockum Limestone is probably somewhat older than the lowermost limestone layer in the Höhne valley. From a restudy of the Stockum fauna he concluded that *Gattendorfia* had not been found there. On the other hand he pointed out, that the characteristic feature of the suture of the genus *Gattendorfia* is also represented in several species of the genus *Imitoceras*. This characteristic is the position of the lateral lobe, normally in *Imitoceras* just at or inside of the umbilical seam, but in *Gattendorfia* outside. After VÖHRINGER these two genera differ from each other in the style of coiling. *Gattendorfia* is evolute. *Imitoceras* is normally involute; only some evolved species from the *Gattendorfia* stage are evolute in the earliest whorls.

WEYER (1965) followed VÖHRINGER's concept and referred all species from Stockum to *Prionoceras* (*Imitoceras*). He assumed that H. SCHMIDT had determined a juvenile specimen of *Pr. (Imitoceras)* as *Gattendorfia crassa*.

In our newly collected fauna from the Stockum Limestone in a single sample of about 1.000 cm³ more than a thousand goniatite specimens were found, mostly juvenile forms. *Gattendorfia subinvoluta* has not been found, while some specimens show evolute early whorls and the lateral lobe lies outside the umbilical seam.

Unfortunately the related forms (these are the species of *Imitoceras*) from the uppermost Devonian have not yet been studied so thoroughly as those of the *Gattendorfia* stage. But first investigations on SCHINDEWOLF's unpublished *Imitoceras* material from the uppermost layers of the *Wocklumeria* stage in the Höhne valley, as well as our own material, show that the lateral lobus is not outside of the umbilical seam and the inner whorls are all clearly involute. These facts arouse the suspicion that both characteristics — evolute whorls and lateral lobe outside the umbilical seam — occur for the first time after the extinction of the clymenids. If further investigations confirm this assumption we should draw the Devonian/Carboniferous boundary below the Stockum Limestone. This would be in accordance with the intention of the decision of Heerlen in 1935, even if the Stockum Limestone is somewhat older than the lowermost limestone layer of the *Gattendorfia* stage in the Höhne valley, as the author believes.

2.3.2. Trilobites

The uppermost records of trilobites which are undoubtedly of Upper Devonian age are from member B ("Dasberg-Schichten" sensu H. SCHMIDT, 1924) of trench II. These records (samples 1008/201, 202, 203) are more than 15 m below the Stockum Limestone.

Some of these species are provisionally listed in open nomenclature. They are probably further evolved descendants of Upper Devonian species, not yet described:

Drevermannia cf. *schmidti* RUD. RICHTER, 1913

Typhloproetus sp.

Chaunoproetus (*Ch.*) *stockumensis* H. ALBERTI, 1974

Phacops (*Dianops*) cf. *griffithides* (RUD. & E. RICHTER, 1919)

Phacops (*Cryphops?*) *ensae* RUD. & E. RICHTER, 1926

Phacops (*Cryphops?*) *wocklumeriae* RUD. & E. RICHTER, 1926

The next higher records are a short distance below the Stockum Limestone. In trench I, 15 cm below the Stockum Limestone (sample 1008/102), occur:

Cyrtosymbole (*Macrobole*) *duodecimae* RUD. & E. RICHTER, 1951
(badly preserved Cranidium)

"*Drevermannia*" *moravica* CHLUPÁČ, 1956, n. ssp.

Meraspis-stadium

In trench II approximately 30 cm below the Stockum Limestone (sample 1008/923) occur:

Cyrtosymbole (*Waribole*) *abruptirhachis* (RUD. & E. RICHTER, 1919)

Cyrtosymbole (*Macrobole?*) *ogivalis* RUD. & E. RICHTER, 1951

"*Drevermannia*" *moravica* CHLUPÁČ, 1956, n. ssp.

In the Stockum Limestone itself (sample 1008/200) were found:

Cyrtosymbole (*Waribole*) *abruptirhachis* (RUD. & E. RICHTER, 1919)

C. (Macrobole) *drewerensis drewerensis* (RUD. & E. RICHTER, 1951)

C. (M.) drewerensis longisuta RUD. & E. RICHTER, 1951

C. (M.) drewerensis n. ssp. RUD. & E. RICHTER, 1951

C. (M.) duodecimae RUD. & E. RICHTER, 1951

C. (M.) hercules RUD. & E. RICHTER, 1951

"*Drevermannia*" *moravica* CHLUPÁČ, 1956, n. ssp.

From these species RUD. & E. RICHTER (in H. SCHMIDT, 1924, 1929 and RUD. & E. RICHTER, 1951) reported only *C. (W.) abruptirhachis* as occurring in the Stockum Limestone. They put the species into the Lower Carboniferous, since it occurs at its locus typicus and stratum typicum (Quarry east of Kirchgattendorf, layer 21 of SCHINDEWOLF, 1923) together with *Gattendorfia subinvoluta*.

In 1951 RUD. & E. RICHTER reported the occurrence of *C. (W.) abruptirhachis* and the type of *C. (M?) ogivalis* RUD. & E. RICHTER, 1951 in one piece of rock as well as *C. (W.) abruptirhachis* and *C. (M.) hercules* in some other pieces.

These records were made in the "Provincialsteinbruch" near Drewer. There the layers, containing the mentioned fossils, are above the *Wocklumeria* stage and consequently placed in the Lower Carboniferous. In the same way H. OSMÓLSKA (1962) put beds with *C. (W.) abruptirhachis* from the Holy Cross Mountains in Poland into the *Gattendorfia* stage.

2.3.4. Ostracodes

For the first time, here in Stockum we have a single profile covering the region of the Devonian/Carboniferous boundary and consisting mainly of pelitic and silty sediments and containing some layers rich in ostracodes. Entomozoid ostracodes were found in and above the layers with limestone nodules, placed by ZIEGLER (1969: 347) in the upper *costatus* zone of the conodont zonation. After RABIEN (1954, 1960), GRÜNDEL (1961) and others they are typical for the uppermost Upper Devonian. The samples 1008—889 and 890 from trench II contain, besides conodonts of the Middle *costatus* zone, ostracodes of the Upper *hemisphaerica-dichotoma* time (compare GROSS-UFFENORDE & UFFENORDE, 1974):

- Richterina (Richterina) costata* (RH. RICHTER, 1869)
Richterina (Richterina) striatula (RH. RICHTER, 1848)
Maternella dichotoma (PAECKELMANN, 1913)
Maternella hemisphaerica (RH. RICHTER, 1848)

In the lowermost part of member C in trench II were found abundant ostracodes (1008—886) indicating the *hemisphaerica latior*-Interregnum (after RABIEN, 1960 it is a transitional horizon, of which the large part still belongs to the Upper Devonian):

- Richterina (Richterina) costata* (RH. RICHTER, 1869)
Richterina (Richterina) striatula (RH. RICHTER, 1848)

Immediately below the Stockum Limestone only a few entomozoid ostracodes (samples 1008—922, 923) were found within layers rich in posidoniids. Among the ostracodes are no typical Upper Devonian species (compare GROSS-UFFENORDE & UFFENORDE, 1974):

- Maternella circumcostata* RABIEN, 1960?
Maternella n. sp. 3
Maternella sp. 4

Richterina (Richterina) latior RABIEN, 1960, regarded as characteristic for the *Gattendorfia*-stage in the Rhenish and Thuringian Schiefergebirge, first occurs approx. 5 m above the Stockum Limestone (trench II, sample 1008—891).

Thus an additional Ostracod fauna is intercalated between the *hemisphaerica latior*-Interregnum and the *latior* time. The species of this fauna do not occur with fossils of undoubtedly Upper Devonian age, but they are present higher in the Lower Carboniferous.

2.3.3. Conodonts

Introductory remarks: In order to avoid misunderstandings, the following terminology will be used:

- a) Younger *Protognathodus* fauna (younger *Pr. f.*): With *Pr. meischneri*, *Pr. collinsoni*, *Pr. kockeli*, *Pr. kuehni*
 b) Older *Protognathodus* fauna (older *Pr. f.*): without *Pr. kuehni*

Pr. meischneri ZIEGLER, 1969 is synonymous with

Gnathodus cf. *commutatus* (BRANSON & MEHL) in SCOTT, 1961 [? partim, most probably including *Pr. collinsoni*]

Gnathodus cf. *G. commutatus* in SCOTT & COLLINSON, 1961, Pl. 1, Fig. 26, 27 [non Fig. 23, 24, 25 = *Pr. collinsoni*]

Gnathodus n. sp. A in COLLINSON, SCOTT & REXROAD, 1962 [? partim, most probably including *Pr. collinsoni*]

Pr. collinsoni ZIEGLER, 1969 is synonymous with

? partim *Gnathodus* cf. *G. commutatus* (BRANSON & MEHL) in SCOTT, 1961 [but mainly *Pr. meischneri*]

Gnathodus cf. *G. commutatus* (BRANSON & MEHL) in SCOTT & COLLINSON, 1961, Pl. 1, Fig. 23, 24, 25 [non Fig. 26, 27 = *Pr. meischneri*]

Pr. kuehni ZIEGLER & LEUTERITZ, 1970 (in KOCH et al.) is synonymous with *Gnathodus* n. sp. B in COLLINSON, SCOTT & REXROAD, 1962, Fig. 3; *Protognathodus* n. sp. A in ZIEGLER (1969), Pl. 1, Fig. 6

The Stockum Limestone is the stratum typicum for the so-called *Protognathodus* fauna of ZIEGLER (1969). The type material has been cut by Prof. Dr. D. MEISCHNER from the original material of H. SCHMIDT's (1924) *Imitoceras* fauna, which is deposited in the collection of the Geologisch-Paläontologisches Institut in Göttingen.

The first described species of the genus *Protognathodus*, *Pr. kockeli*, was considered by BISCHOFF (1957) as an important index fossil of the early Lower Carboniferous. This was confirmed by VOGES (1959 and 1960). From the Louisiana Limestone of Western Illinois SCOTT as well as SCOTT & COLLINSON mentioned in 1961 *Pr. meischneri* (?) and *Pr. collinsoni* under the name of *Gnathodus* cf. *Gn. commutatus* (BRANSON & MEHL). Since they obviously had a mixed fauna with numerous Upper Devonian forms, they put it (it is the older *Pr. f.*) into the Upper Devonian.

COLLINSON, SCOTT & REXROAD (1962) also placed the older *Pr. f.* of the Louisiana Limestone into the Upper Devonian and called it *Gn. n. sp. A* assemblage. The younger *Pr. f.* from the Glen Park and from the basal Hannibal they put into the Lower Carboniferous as *Gn. n. sp. B* — *Gn. kockeli* zone.

ZIEGLER (1969: 356) put both *Pr. f.* into the Upper Devonian. He assumed that the Stockum fauna is either equivalent to the younger *Pr. f.* or has to be placed between the two *Pr. f.* As already mentioned by ZIEGLER in an addendum to his 1969 paper, ZIEGLER & LEUTERITZ (1970: 701) considered, that the fauna with *Pr. kuehni* (that is the younger *Pr. f.*) belongs between the *Pr. f.* from Stockum and the first conodont zone of the *Gattendorfia* Limestone.

COLLINSON, REXROAD & THOMPSON (1971) placed the older *Pr. f.* into the Upper Devonian and the *Pr. kuehni* — *Pr. kockeli* zone into the Lower Carboniferous, below the *Siphonodella sulcata* zone, corresponding to COLLINSON, SCOTT & REXROAD (1962).

SANDBERG, STREEL & SCOTT (1972) incorporated the *Pr. kuehni* — *Pr. kockeli* zone (that is the younger *Pr. f.*) into the *sulcata* zone as the oldest zone within the Lower Carboniferous. Their "*Protognathodus* fauna" (that is the lower *Pr. f.*) was left in the Upper Devonian and correlated with the upper part of the range of *Siphonodella praesulcata* SANDBERG, 1972.

At Stockum we have the following conodont succession from the lower to upper parts of the section:

1) Upper *costatus* zone: the last evidence is approx. 13,5 m below the Stockum Limestone (sample 1008—886)

2) *Pr. f.* with *Pr. kockeli* and *Siph. praesulcata* was found at the top of layer Ca, that is 40 cm below the Stockum Limestone (sample 1008—303). *Siph. praesulcata* is characteristic for a clastic facies, which in North America is placed into the Upper Devonian (SANDBERG, STREEL & SCOTT, 1972). However this species itself extends into the Lower Carboniferous.

3) *Pr. f.* with *Pr. meischneri*, *Pr. collinsoni*, *Pr. kockeli* and *Pr. kuehni* in the Stockum Limestone (sample 1008—330).

4) *Pr. f.* with *Polygnathus purus subplanus* VOGES in the layer Ce, 30 cm above the Stockum Limestone (samples 1008—331 and 305).

Pr. kuehni characterizes the younger *Pr. f.*. According to the American authors the Stockum fauna must be placed in the Lower Carboniferous, in spite of the scarcity of *kuehni*.

Whether the *Pr. kuehni* is found depends on the sample quantity and some luck. Sample 1008—330 yielded one specimen of each of the four species of *Protognathodus*, while in sample 1008—294 among 170 *Protognathodus* specimens no *Pr. kuehni* was found). Therefore this subdivision of the *Pr. f.* is still quite unsatisfactory. However, the evolution within the closely related species group *Spathognathodus stabilis* (BRANN & MEHL, 1934), *Pr. meischneri*, *Pr. collinsoni*, *Pr. kockeli*, *Pr. kuehni* might, upon additional investigations, provide valuable criteria for a detailed subdivision.

2.3.5. Spores

Spores from the Stockum Limestone were cited first in 1970 by STREEL (in PAPATH & STREEL). He pointed out that the Stockum Limestone has to be placed in the lower part (PLs 3) of his florizone with *Hymenozonotriletes lepidophytus* and *Valisporites pusillites*. The upper PL-florizone (PLs 1) is also present in beds, which are related with the bed, in which DELEPINE (1929) found the Upper Devonian *Cymaclymenia euryomphala*. This seemed to confirm the Upper Devonian age of the Stockum Limestone and has also been used as an argument by subsequent authors (AUSTIN et al. 1970; SANDBERG, STREEL & SCOTT, 1972; H. SCHMIDT, 1972).

The investigation of additional samples from the trenches I—III as well as those from other localities gave some new results (compare STREEL, 1974): In the PLs 3 part the former *lepidophytus* — *pusillites* florizone *H. lepidophytus* is sometimes absent as with *V. pusillites*, less abundant than in the parts below. On the other hand, in PLs 3 flora murornated spores, abundant also in the younger florizone with *Dictyotetes trivialis* and *H. explanatus*, become dominant for the first time. STREEL (1974) therefore now included this former PLs 3 flora in the *trivialis-explanatus* florizone. The already established dominance of the murornated forms just below the Stockum Limestone excludes an age correlation with the *Cymaclymenia euryomphala* bearing Upper Devonian beds. The Stockum Limestone is younger than these.

In text-fig. 2, samples 1008/106, 135, 138, 145 from trench I and 1008/111, 112, 117, 151 from trench II still belong to the *lepidophytus-pusillites* florizone. In

samples 1008/101, 102, 103, 140, 141 from trench I and 1008/119, 149 from trench II the murornated spores dominate. Therefore they are now placed in the *trivialis-explanatus* florizone.

3. Chronology

3.1. The establishment of the Devonian/Carboniferous boundary at the Heerlen Congress in 1935

During the Congrès pour l'avancement et des études de stratigraphie carbonifère at Heerlen in 1935 an agreement about the Devonian/Carboniferous boundary was reached.

According to the proposal of PAECKELMANN and SCHINDEWOLF, the boundary should be placed above the last clymenids and below the *Gattendorfia* stage („soll die Grenze gelegt werden oberhalb der letzten Clymenien, unterhalb der *Gattendorfia*-Stufe“, JONGMANS & GOTHAN, 1937: 4). As a criterion of the Devonian/Carboniferous boundary, the first occurrence of *Gattendorfia subinvoluta* can be employed („Als Kriterium der Grenze Devon/Karbon kann das Erscheinen von *Gattendorfia subinvoluta* angenommen werden“, J. & G., 1937: 7). The standard section according to PAECKELMANN'S proposal ought to be the completely exposed section from the Hönne valley in the Sauerland (J. & G., 1937: 7).

In this decision of Heerlen two important points for the drawing of the boundary are clearly stressed:

- The boundary should be defined by faunal characteristics.
- These characteristics are the extinction of the clymenids on the one hand and the development of new forms on the other.

3.2. The section near Kirchgattendorf

Gattendorfia subinvoluta, used for the establishment of the Devonian/Carboniferous boundary during the Heerlen Congress, is the type species of the genus *Gattendorfia*. The type locality of this species is a quarry near Kirchgattendorf in the Voigtland (1:25.000 mapsheet, 5638 Bobenneukirchen; coordinates: 76585/00550). A thorough description of the section for this quarry was published by SCHINDEWOLF (1923). Above a layer of cephalopod limestone with clymenids of the Upper Devonian *Wocklumeria* stage (bed. no. 20) follows layer no. 21, which SCHINDEWOLF measured as 30 cm thick. This is the stratum typicum of *Gattendorfia subinvoluta* and also, after RUD. & E. RICHTER, C. (W.) *abruptirhachis*.

In course of a re-collection at the type section, the important layer no. 21 was subdivided. Already in the lowermost 6 cm thick part, the following fauna was found in addition to various species of the genus *Imitoceras*:

- Gattendorfia* sp. (juvenil, *G. subinvoluta* vel *G. crassa*)
- C. (W.) *abruptirhachis*
- C. (M.) cf. *drewerensis*
- Pr. meischneri*
- Pr. collinsoni*
- Pr. kockeli*
- Pr. kuehni*

In respect to the conodont fauna and *C. (W.) abruptirhachis*, the stratum typicum of *Gattendorfia subinvoluta* is equivalent to the Stockum Limestone.

3.3. Discussion and conclusions

If the index fossil is missing — in our case *G. subinvoluta* — the age must be determined with the help of other available fossils. Applying this method to the Stockum Limestone, its fauna should be placed in the Lower Carboniferous.

Since in recent publications the Stockum Limestone was put into the Upper Devonian, a proof for its lower carboniferous age must be especially convincing. This is valid, although the important fossils of the Stockum Limestone were never found together with index fossils of Upper Devonian age. The proof is complicated by the fact that the Stockum fauna has not yet been identified with certainty within the standard section from the Hönne valley. Perhaps it is represented in the uppermost part of the Hangenberg shales, where PAPROTH (described in PAPROTH & STREEL, 1970) found some specimens of the genus *Imitoceras*. However, a gap in the sequence as assumed by PAPROTH & STREEL (1970) can not be ruled out.

a) Up to now *Gattendorfia subinvoluta* has not been found in the Stockum Limestone. It is possible that this limestone had been deposited before the first occurrence of this more advanced species. This possibility can certainly not be excluded. On the other hand the characteristics of the genus *Gattendorfia* are already clearly indicated in some elements of the Stockum fauna. If further investigations will confirm this assumption, the Devonian/Carboniferous boundary should be drawn below the Stockum Limestone in accordance with the decision at Heerlen in 1935; i.e. above the extinction of the clymenids, below the evolution of new characteristics in the goniatites.

b) The trilobites from the Stockum Limestone have never been found together with undoubtedly Upper Devonian fossils, but only with those of certain Lower Carboniferous age.

c) As for the trilobites the same is true for the ostracodes.

d) There is a characteristic change in the composition of spore floras just below the Stockum Limestone.

e) The 4 species of the conodont genus *Protognathodus* are also present in beds of undoubtedly Lower Carboniferous age. At least the occurrence of the more advanced species together with Upper Devonian fossils is not yet proved.

f) The incorporation of the Stockum Limestone in the Carboniferous would have some practical advantages. Then, even with a few conodonts, or trilobites or ostracodes, and probably also with only a few spores or goniatites, a clear age determination would be possible. Further more the intention of the Heerlen decision to draw the boundary between the systems at a prominent faunal change would be preserved. On the other hand the boundary could be fixed within the evolutionary development of at least goniatites and conodonts.

g) A definitive and more precise specification of the Devonian/Carboniferous boundary should be made only after thorough investigation of the mentioned evolutionary lines.

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