Lower Carboniferous Conodonts from the Cima di Plotta Section (Carnic Alps, Italy)

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With 6 Text-Figures and 6 Plates

Contents

Conodonten aus dem Unterkarbon des Cima di Plotta-Profils (Karnische Alpen, Italien)

Zusammenfassung

Im Profil Cima di Plotta auf der Südseite der Karnischen Alpen (Italien) kommen in einer Mächtigkeit von 7.04 m im Hangenden von devonischen Flachwasserkalken unterkarbonische Cephalopodenkalke vom Typ des Kronhofkalkes vor, die eine reiche Conodontenfauna führen. Sie reicht von der anchoralis-latus-Zone bis zum vermuteten Beginn der bilineatus-Zone, d.h. entsprechend der belgischen Gliederung vom jüngeren Tournai bis in das ältere Visé (Pericyclus-Stufe, cu II γ). Die vorgefundenen Kalke stellen somit die jüngsten karbonatischen Bildungen vor Einsetzen der Flyschfazies (Hochwipfel Formation) am Ende des variszischen Sedimentationszyklus dar. Dem Flysch ging eine Verkarstung voran, die nach den Neubefunden etwas jünger ist, als bisher angenommen wurde.

Abstract

On the Italian side of the Carnic Alps the newly discovered Cima di Plotta section provided a rich and diversified Lower Carboniferous conodont fauna. The 7.04 m thick goniatite bearing limestone sequence is subdivided into 6 informal faunal units each characterized by a distinct conodont association. It ranges from the anchoralis-latus to the presumed base of the bilineatus-Zone. In general our collection confirms the standard

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conodont based subdivision for the time span from the late Tournaisian to the lower Visean. The lower part of the section is almost equally represented by specimens of *Gnathodus* and *Scaliognathus*, the upper portion, however, is strongly dominated by species of *Gnathodus*. Our biofacies analysis suggests an off-shore pelagic setting prior to a paleokarst event of lower Visean age.

The conodont bearing sequence represents the youngest limestones of the Variscan sedimentary cycle which corresponds to the Pericyclus IIγ Stage of the Lower Carboniferous. They were succeeded by the flysch facies of the Hochwipfel Formation during the remaining part of the Visean and the early Upper Carboniferous.

The abundance of conodonts, in particular of representatives of *Gnathodus* and *Scaliognathus* makes the Cima di Plotta section one of the best places in which evolutionary lineages and the relationships between taxa of this time interval can be studied in detail.

1. Introduction

During the past more than 30 years for the equivalence of the Tournaisian Stage (Lower Dinantian Series) a world-wide° applicable conodont zonation has been established. In terms of conodont biozones the boundary with the following Visean Stage, i.e., the Tn3c/V1a boundary, however, seems less well defined (H.R. LANE & W. ZIEGLER, 1983; S.-I. PARK, 1983, 1986; R. CONIL et al., 1989; G.D. WEBSTER & E. GROESSENS, 1991). According to E. GROESSENS (1976), E. GROESSENS & B. NOEL (1977) and R. CONIL et al. (1989) at the Bastion section of the Belgian boundary stratotype the conodont sequence changes approx. 7 m below the boundary (bed no. 122) from *Scaliognathus anchoralis europensis* to *Mestognathus beckmanni* (the first occurrence of its forerunner *M. praebeckmanni* is already some 15 m below this level). In bed no. 143, i.e. slightly above the boundary marker bed 141, *M. beckmanni* is followed by the first appearance of *Gnathodus homopunctatus*. Whether or not these transitions are true or an effect of the changing lithofacies has been a matter of debate for some time (H.R. LANE et al., 1980; P. BRENCKLE & H.R. LANE, 1981; H.R. LANE & W. ZIEGLER, 1983; R. DREESEN et al., 1986). According to R. CONIL et al. (1976), E. GROESSENS & B. NOEL (1977) and others the lithology of the boundary stratotype reflects a shallowing event with a regression at the end of the Ivorian (Waulsortian) and the appearance of intraclasts and oolites at or close to the base of the Visean.

Such sea-level changes may well explain the different conodont assemblages across the boundary interval and the vertical distribution of key genera. In fact, R. DREESEN et al. (1986) argued that some of the conodont zones of the Belgian Dinantian may represent successive biofacies rather than conodont chronozones. Such deficiencies may not apply to the classical "Route de Salet" section which serves as a parastratotype for the Lower Visean of the Dinant Synclinorium (E. CONIL, 1967). According to Z. BELKA & E. GROESSENS (1986) at this locality all such conodonts were recognized which characterize the interval from the Upper Tournaisian to the Lower Visean sensu E. GROESSENS.

In general, conodont distribution of Dinantian rocks follows the scheme proposed by C.A. SANDBERG & R.C. GUTSCHICK (1979, 1980, 1984). This "SANDBERG-GUTSCHICK model" is similar to the worldwide recognized scheme for the Late Devonian (C.A. SANDBERG, 1976; C.A. SANDBERG et al., 1988) and includes seven conodont biofacies. Accordingly, the scaliognathodid-doliognathodid biofacies (II) extends from the lower foreslope to starved basin settings, i.e., represents an offshore pelagic environment whereas the mestognathid biofacies is restricted to unfavorable living conditions of landward tidal lagoons and sabkhas (P.H. v. BITTER et al., 1986).

The above mentioned pattern also applies to carbonate shelf faunas of Dinantian rocks of the British Isles which show a similarly clear distinction with those from the coeval basinal habitats (R.L. AUSTIN & R.B. DAVIES, 1984).

For the Visean a preliminary standard conodont zonation was first proposed by H.R. LANE et al. (1980). It was later confirmed by I.S. BARSKOV et al. (1987), W. ZIEGLER & H.R. LANE (1987) and G.D. WEBSTER & E. GROESSENS (1991). Different from earlier local zonations it is based largely on evolutionary lineages of taxa with first appearances of important species to define the base of the corresponding zone. The main advantage of this new scheme is its employment of taxa which inhabited the open marine pelagic realm and hence suggested global application instead of local facies-controlled ranges.

To summarize, regardless the extent of sea-level fluctuations and its implications for ranges of key taxa at the Belgian boundary stratotype, in terms of the currently used conodont zonation and based on rarely occurring goniatites from the eastern Rhenish Mts. of Germany and the Cantabrian Mts. of Spain, the majority of authors consider the base of the *Gn. texanus* Biozone to coincide with the base of the Visean at the stratotype (A.C. HIGGINS & C.H.T. WAGNER-GENTIS, 1982; S.-I. PARK, 1983, 1986; W. ZIEGLER & H.R. LANE, 1987; I.S. BARSKOV et al., 1987; G.D. WEBSTER & E. GROESSENS, 1991). Less well studied is, however, the correlative potential of the succeeding conodont zones, in particular in relation with the standard goniatite sequence to establish interregional correlation between different facies belts during the Visean. Presently, only for the shallow water platform sequences a detailed correlation scheme between conodonts, foraminifers and rugose and tabulate corals has been provided (R. CONIL et al., 1991).

In this contribution we present the results of a conodont study from a 7.04 m thick pelagic limestone section in the Carnic Alps of Northern Italy. The highly varied and rich conodont fauna represents an open marine pelagic environment in which scaliognathodids and gnathodids are the dominating elements. The fully exposed section ranges from the lower *Scaliognathus anchoralis-Doliognathus latus*-Zone to the first appearance of *Gn. girtyi* and, presumably, early representatives of *Gn. bilineatus bilineatus* which are named herein *Gn. praebilineatus*. It thus provides additional faunal evidence for the conodont-based subdivision of the Tournaisian/Visean boundary and the lower Visean.

2. Local Geology

For more than 30 years in the Carnic Alps of Northern Italy and Southern Austria a conodont-based biostratigraphy has been successfully applied to various sedimentary sequences to unravel the complex geologic history during the Variscan Period. This cycle ended after deposition of the flysch-type Hochwipfel Formation in the late Bashkirian or early Moscovian Stage of the early Upper Carboniferous.

With the exception of few plant occurrences the clastic and more than 1200 m thick Hochwipfel Fm. is unfossiliferous. With reference to the underlying fossiliferous basement rocks a maximum age within the *Scaliognathus anchoralis-Doliognathus latus*-Zone, i.e., ± the base of the Visean has been assumed for the onset of the flysch deposition. This age is in excellent accordance with a rich occurrence of plant fossils including well preserved leafs approx. 1 km to the west of Cima di Plotta section which suggest a Middle Visean age for the lower portion of the Hochwipfel Formation (H.W.J. VAN AMEROM et al., 1984; H.P. SCHÖNLAUB et al., 1991).

In the Carnic Alps continuity of sedimentation during the Late Devonian and across the Devonian/Carboniferous boundary has long been documented (H.R. V. GAERTNER, 1931; C. SPALLETTA, 1982; H.P. SCHÖNLAUB et al., 1991, 1992, with further references). Exceptions, however, do occur: At some former shallow water localities Carboniferous limestones rest disconformably upon the Devonian and stratigraphic gaps may range from the early Upper Devonian to almost the end of the Tournaisian. Obviously, truncation and a significant paleorelief were caused by sea-level fluctuations, block faulting and subsequent erosion in an extensional regime during the late Devonian or early Carboniferous (C. SPALLETTA, 1982). In addition a broad spectrum of distinct paleokarst features of Lower Carboniferous age has been recognized recently (H.P. SCHÖNLAUB et al., 1991; B. HENTSCHEL & M. KERN, 1992). It resulted in extensive limestone dissolution, formation of caves, fissures and breccias, mixed faunas and stratabound ore deposits. According to H.P. SCHÖNLAUB et al. (1991) this event occurred during the *Scaliognathus anchoralis-Doliognathus latus*-Zone.

Section Cima di Plotta belongs to the Kellerwand Nappe of L.H. KREUTZER (1990). Stratigraphically the more than 1200 m thick nappe ranges from the Upper Ordovician to the Carboniferous. The Devonian part of the sequence is developed in intertidal, back-reef or reef facies and thus contrasts with the underlying Cellon nappe which displays the transition to a pelagic setting. Originally both units were closely related showing the Kellerwand block in a position not more than 4 to 5 km to the SSW of the Cellon block (L.H. KREUTZER, 1990).

Based on detailed conodont studies for the Cellon Nappe continuous and uniform sedimentation during the Upper Devonian and the lower part of the Tournaisian has been well documented (K. BANDEL, 1972; I. GEDIK, 1974; H.P. SCHÖNLAUB et al., 1988, 1992; L.H. KREUTZER, 1990). For the neighbouring Kellerwand Nappe, however, such a transition has yet not been demonstrated. According to L.H. KREUTZER (1990) continuous sedimentation lasted until the late Famennian *P. postera*-Zone (previously named *styriacus*-Zone). Yet there is no fossil evidence of any younger rocks except the area to the west and east of Rifugio Marinelli where well dated Carboniferous strata were found to rest disconformably upon the amphiporid bearing shallow water Spinotti Limestone of presumably Middle Devonian age (K. BANDEL, 1972; S. POHLER, 1982; L.H. KREUTZER, 1990, 1992a; C. SPALLETTA, 1982 – with unknown relationship to the Devonian part of the sequence). Our report deals with the area east of Rifugio Marinelli where the Cima di Plotta section is located.

3. The Cima di Plotta Section

The Plotta mountain is located on the Italian part of the Carnic Alps south of the Creta di Chianevate-Monte Coglians range (=Kellerwand Massif) at an altitude between 1870 and 1890 m. More precisely, it is situated some 550 m to the east of Rifugio Marinelli and some 1500 m south of the La Chianevate cliff. The section is exposed 200 m to the northeast of Cima di Plotta near the trail numbered 146 leading from Plöcken Pass (Passo di M. Croce Carnico) to Rifugio Marinelli. Access is also possible through use of a mountain road which starts from the main route no. 52b to Rifugio Marinelli (see Text-Fig. 1).
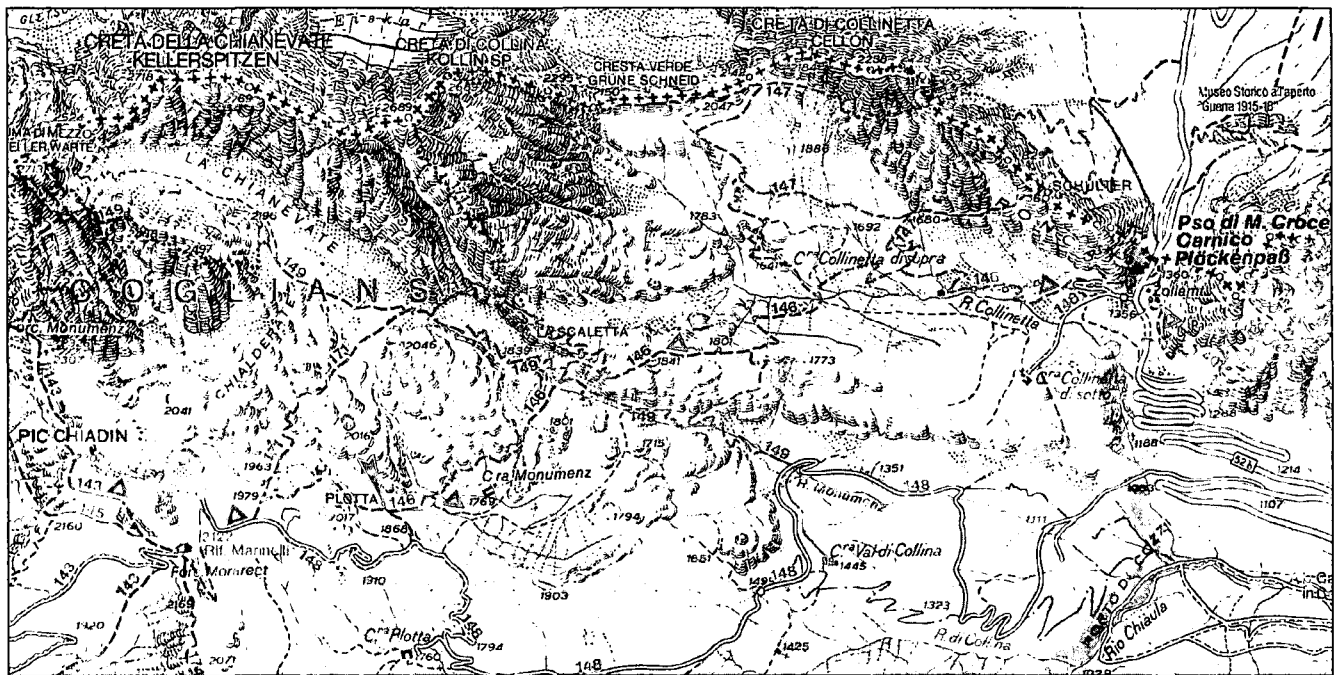
Text-Fig. 1.
Location of Cima di Plotta section in the central Carnic Alps of northern Italy (see arrow).
Topography after Carta Topografica per escursionisti 1 : 25.000, Foglio 09, Tabacco, Casa Editrice, Udine.
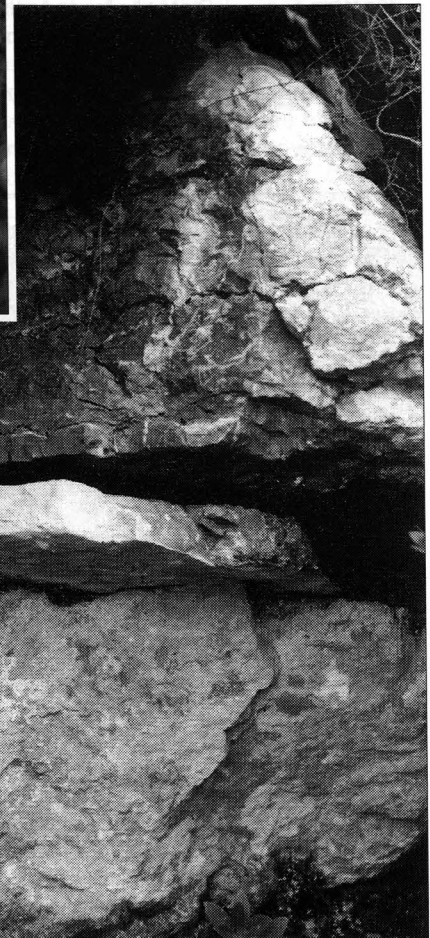
Text-Fig. 2. ▶▶
Cima di Plotta section showing the light massive Spinotti Lst. (Givetian or early Frasnian below) and the overlying Kronhof Limestone (Lower Carboniferous).
Arrow indicates the disconformity plane shown on Text-Figs. 3, 4.

Text-Fig. 3. ▼▼
Disconformity plane between the Spinotti and the Kronhof Lst.
Sample no. 52 applies to the rock immediately above the upper edge of the chisel.

Text-Fig. 4. ▼▼
Detail of Text-Fig. 3.
Contact between the Givetian (or early Frasnian) Spinotti Lst. and strata assigned to the lower *Sc. anchoralis-latus*-Zone of the Lower Carboniferous (no. 51).

The section was measured and sampled along the steep 20 m high cliff some 30 m to the northeast of the mentioned trail (Text-Fig. 2).

The upper portion is easily accessible, the lower part, however, had to be studied by help of alpinistic methods. In total 30 samples were collected and processed for conodonts and/or prepared for thin section analysis. Sample weight varied between 1.770 and 3.468 kg (Text-Fig. 5).

3.1. Location, Lithology, Microfacies and Fossil Content

The section starts at an altitude of approx. 1870 m. The major part of the cliff exposes unbedded grayish limestones with abundant amphiporids, corals and other fossil debris. Lithologically they are assigned to the Spinotti Lst. of Middle to Upper Devonian age. This type consists of predominantly coated grains ("coated-grain limestone" s. L.H. Kreutzer [1992a]) with amphiporids, pellets, grapes
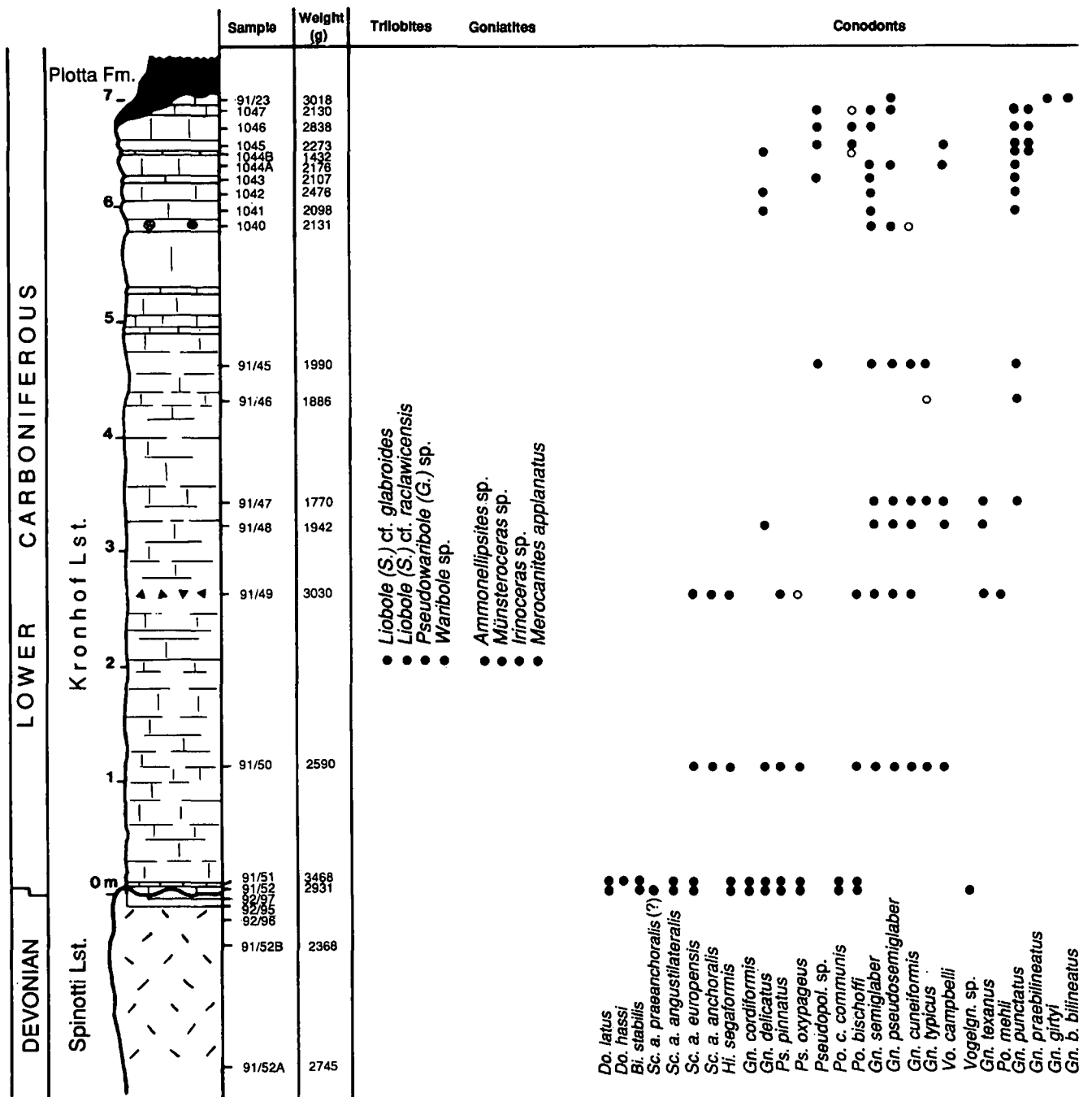
Text-Fig. 5.
Distribution of trilobites, goniatites and conodonts from the Kronhof Limestone of Cima di Plotta section.

Column headers: Sample | Weight (g) | Trilobites | Goniatites | Conodonts

Stratigraphic units (left side): Plotta Fm. / LOWER CARBONIFEROUS / Kronhof Lst. / DEVONIAN / Spinotti Lst.

Samples and weights:
91/23 — 3018
1047 — 2130
1046 — 2838
1045 — 2273
1044B — 1432
1044A — 2176
1043 — 2107
1042 — 2476
1041 — 2098
1040 — 2131
91/45 — 1990
91/46 — 1886
91/47 — 1770
91/48 — 1942
91/49 — 3030
91/50 — 2590
91/51 — 3468
91/52 — 2931
92/97
92/95
92/96
91/52B — 2368
91/52A — 2745

Trilobites: Liobole (S.) cf. glabroides, Liobole (S.) cf. raclawicensis, Pseudowaribole (G.) sp., Waribole sp.

Goniatites: Ammonellipsites sp., Münsteroceras sp., Irinoceras sp., Merocanites applanatus

Conodonts: Do. latus, Do. hassi, Bi. stabilis, Sc. a. praeanchoralis (?), Sc. a. angustilateralis, Sc. a. europensis, Sc. a. anchoralis, Hi. segaformis, Gn. cordiformis, Gn. delicatus, Ps. pinnatus, Ps. oxypageus, Pseudopol. sp., Po. c. communis, Po. bischoffi, Gn. semiglaber, Gn. pseudosemiglaber, Gn. cuneiformis, Gn. typicus, Vo. campbelli, Vogelgn. sp., Gn. texanus, Po. mehli, Gn. punctatus, Gn. praebilineatus, Gn. girtyi, Gn. b. bilineatus

similar to the occurrences of the Chianeveta – Mt. Coglians (= Kellerwand – Hohe Warte) area (KREUTZER, 1990, 1992a, 1992b). The fossil constituents comprises Parathuramminacea, echinodermal fragments, gastropods and shell debris. In the lower part of the section the amphiporids are characterized by micritic envelopes which change in the upper part to micritic seams and finally, to oncoids encrusting the amphiporids; these types are accompanied by rather large broken grapestones (sample 91/53).

There is a significant change in lithology some 17.5 m above the base of the cliff. The uppermost unbedded level (sample nos. 91/52b, 92/96) is characterized by fairly abundant authigenic quartz grains; coated grains are almost missing and amphiporids are free of micritic seams.

On the other side Parathuramminacea are more abundant and gastropods also occur. The main textural feature of this rock are birdseye structures. Towards the top of this horizon (sample nos. 92/95, 92/97) the abundance of parathuraminacean foraminifera increases and the fenestral fabric becomes the most distinct feature of the massive limestone.

The overlying 7.04 m thick-bedded Kronhof Limestone comprises a goniatite bearing pelagic limestone. It rests disconformably with a small-scale relief upon the massive amphiporid limestone (Text-Figs. 3,4). The lowermost horizon consists of either goniatite wackestones (sample no. 91/52) or of a 4 cm thick bed (sample no. 91/51) that is characterized by thinly alternating mud/wackestone and mm-thick layers with rounded intraclasts. Obviously they

251

are derived from a shallow water shelf area and were redeposited during increased energy.

The succeeding uniform limestone sequence of the Kronhof Lst. reflects a fully pelagic environment as shown for example in sample 91/50 from one meter above sample 91/51. The wackestone is characterized by a micritic matrix and by different bioclasts like trilobites, goniatites, shell fragments, gastropods and some echinoderm fragments. Locally, algal crusts indicate moderate depths of deposition.

Although the uniform character of this sequence is well displayed from thin-section analysis, at some levels a coarse-grained bioclastic input can be recognized, e.g., at sample no. 91/49 which consists mainly of crinoids or sample no. 1040 showing some corals.

Moreover, below sample no. 91/49 some 50 trilobites and some 20 goniatite specimens were found (Text-Fig. 5). According to G. Hahn and D. Korn the following taxa occur:

Liobole (Sulcubole) cf. glabroides Richter & Richter, 1949
Liobole (S.) cf. raclawicensis (Jarosz, 1909)
Pseudowaribole (Geigibole) sp.
Waribole (Waribole) sp.
Ammonellipsites sp.
Muensteroceras sp.
Irinoceras sp.
Merocanites applanatus

Comments by G. Hahn and D. Korn (written and pers. comm. of Dec. 10, 1992 and Jan. 19, 1993, respectively): The provisionally identified association is well comparable with that from the Erdbach Limestone of the Sauerland area in Germany.

The fauna is dominated by Liobole up to 90 %. The representatives of this genus exhibit small eyes in contrast to those from the two other genera which are characterized by big or very big eyes.

This feature too resembles the mixed nature of the fauna known from the Erdbach Limestone. Although Liobole is most common in the Erdbachian in Central Europe it ranges to the cu IIIα_{1-2}. At this horizon, however, it is very rare. Even in strata equivalent to cu IIδ its earlier prédominance diminishes.

In the Cantabrian Mountains the genus Liobole extends as high as to the Namurian. In conclusion, the trilobite fauna most probably indicates a cu IIγ age and thus suggests an equivalence with the Erdbach Lst. of the Sauerland region of Germany.

The ammonoid fauna from Cima di Plotta section comprises some 20 small specimens. Although this faunule has as yet only been provisionally identified it clearly resembles the goniatites from the Erdbach Limestone of the Sauerland region and thus indicates an age corresponding to the Lower Carboniferous cu IIγ.

The uppermost limestone bed (sample no. 91/23) is disconformably overlain by an up to 7 m-thick grayish and porous chert named Plotta Fm. (Text-Fig. 5). The contact to the underlying limestones displays a distinct micro- and macrorelief which exceeds 2 m over a length of not more than 4 m.

According to H.P. Schönlaub et al. (1992) the petrographic characteristics clearly indicate its subaerial origin as a fossil soil facies. At the southern margin of the limestone sequence the Plotta Fm. represents the base of the Hochwipfel Formation (H.W.J. van Amerom et al., 1984).

4. Conodont biostratigraphy

4.1. The Lower *Scaliognathus anchoralis* (*Doliognathus latus*)-Zone

Our informal subdivision of the *Scaliognathus anchoralis*-Zone is based on early but not earliest representatives of the genus *Scaliognathus*, i.e. *S. anchoralis angustilateralis* together with *S. anchoralis europensis* and of *Doliognathus latus* in our lowermost samples 91/52 and 91/51. It thus confirms the results of H.R. Lane et al. (1980) and H.R. Lane & W. Ziegler (1983) who noted an evolutionary development within the genus *Scaliognathus*. Furthermore they presented a range chart in which *Doliognathus latus* was shown not to range as high as the base of the following *texanus*-Zone.

The corresponding rock sequence is not more than at most 10 cm thick. In reality, however, it may be thicker depending on the recovery of conodonts from the unsampled 1 m-thick horizon between sample nos. 91/51 and 91/50.

In addition the following conodonts are present in these two lowermost samples: *Hindeodella segaformis*, *Polygnathus communis communis*, *Polygnathus bischoffi*, *Pseudopolygnathus pinnatus*, *Pseudopolygnathus oxypageus* MT 2, *Gnathodus cordiformis*, *Gnathodus delicatus*, *Bispathodus stabilis* and *Vogelgnathus* sp. *Dollymae* cf. *hassi* was only found in sample no. 91/51. Yet, only two specimens were found.

In the lower part of the section the conodont association is dominated by the occurrence of representatives of *Gnathodus* followed by *Scaliognathus* and by *Polygnathus* + *Pseudopolygnathus*. *Doliognathus latus*, however, occurs in only few numbers. The relative abundance of the respective genera was counted approx. 500 : 200 : 110 : 10.

Our conodont association mainly represents adult specimens although there is a certain number of gnathodids which rather suggest juvenile growth stages. Such forms are illustrated on Plate 5.

4.2. The Upper *Scaliognathus anchoralis* (*Doliognathus latus*)-Zone

In sample 91/50, i.e. about 1.10 m above the base of the exposed Carboniferous limestone section there is a significant change of the conodont fauna: Although *Scaliognathus anchoralis europensis* still dominates the association its phylogenetic descendant *S. a. anchoralis* becomes a very distinct element of the fauna. It is associated with first appearances of *Gnathodus semiglaber*, *G. pseudosemiglaber*, *G. cuneiformis*, *G. typicus* and several other gnathodids representing transitional forms between these taxa. Other elements still present at this level are *G. delicatus*, *Hindeodella segaformis*, *Pseudopolygnathus pinnatus*, *Ps. oxypageus*, *Polygnathus bischoffi* and *Vogelgnathus campbelli*. This association ranges from sample 91/50 to sample 91/49, i.e., over a thickness of at least 1.50 m. At sample 91/49 we observed the first appearance of *G. texanus* (illustrated on Pl. 5, Figs. 1–3).

4.3. The Horizon with *Gnathodus cuneiformis*

Sample 91/48 was collected 60 cm above no. 91/49 and 3.20 m above the base of the section, respectively. It contained the dominating species *Gnathodus cuneiformis* (59), followed by *G. delicatus* (17), *Bispathodus stabilis* (16), *Gnathodus semiglaber* (7) and *Gnathodus texanus* (1). No representative of *Scaliognathus anchoralis* was found at this level.

4.4. The *Gnathodus punctatus* – *Gnathodus pseudosemiglaber* Assemblage

From sample bed no. 91/47, i.e., 20 cm above no. 91/48 and 3.40 cm above the base of the exposed Carboniferous limestones to bed no. 1044A a distinct conodont assemblage occurs which is dominated by representatives of *Gnathodus punctatus* and *G. pseudosemiglaber*. Other co-occurring taxa are *G. cuneiformis*, *G. semiglaber*, *G. typicus*, *G. texanus* and *Vogelgnathus campbelli*; less important are representatives of *Pseudopolygnathus* and *Polygnathus*. In particular, at sample 91/46 characteristic specimens of *Gnathodus punctatus* occur. Another rare occurrence is *Gnathodus delicatus* which has its lowermost appearance in sample 1041. We have illustrated some of these on Plate 4.

4.5. The *Gnathodus praebilineatus* Assemblage

The appearance of the name-bearer of this assemblage is in bed 1044B, i.e., 6.50 m above the base of the exposed Carboniferous limestone section. In our opinion this species evolved from *Gnathodus punctatus* by the development of a concentric arrangement of nodes on the outer cup in contrast to irregularly distributed nodes. This kind of ornamentation of the outer cup resembles that of *G. bilineatus*. The architecture of the inner cup and the parapet, however, cannot be distinguished from *G. punctatus*. In our section early representatives of *G. bilineatus* appear in the uppermost limestone horizon some 40 cm above the first occurrence of *G. praebilineatus*. This evidence suggests an evolutionary relationship between *G. punctatus*, *G. praebilineatus* and *G. bilineatus* in which the two former species are believed to be forerunners of the latter one.

In this horizon the following taxa are also present: *Gnathodus punctatus*, *G. delicatus*, *G. semiglaber*, *G. praesemiglaber*, *Polygnathus bischoffi*, *praepolygnathus* sp. and *Vogelgnathus campbelli*.

4.6. The Horizon with *Gnathodus girtyi*

The uppermost limestone sample no. 91/23 yielded only representatives of the genus *Gnathodus* which were assigned to early occurring specimens of *G. bilineatus* (12), *G. girtyi* (4) and *G. praesemiglaber* (1). Though the abundance is rather low identification of these species seems well founded. For comparison we refer to our figured specimens.

The representatives of *G. bilineatus* resemble *Gnathodus* n.sp. A. EBNER illustrated by S.I. PARK (1983) from the Cantabrian Mountains and the Renish area (Velbert Sattel). In both regions the first occurrence of *Gnathodus* n.sp. A EBNER is in the upper part of the *G. texanus*-Zone. An additional agreement between the Carnic Alps and the Rhenish Mountains (borehole Velbert-4) is its association with first occurrences of *Gnathodus girtyi* (S.-I. PARK, 1983, 1986).

5. Comparison with the Standard Conodont Zonation

As far as the lower part of the Cima di Plotta section is concerned there is no difficulty to correlate these strata with the *Scaliognathus anchoralis* (*D. latus*)-Zone. The question one may raise is the upper limit of this zone, and more precisely, whether or not the equivalents of this particular zone may range higher up than traced here. For several reasons this possibility can be ruled out: From the uniformity of the rock sequence and its facies development we conclude that the true upper range of *Scaliognathus anchoralis* is between sample nos. 91/49 and 91/48, i.e. within an 60 cm thick interval. Below this level the most advanced representative of *Scaliognathus*, i.e. *S. anchoralis anchoralis* occurs. They are associated with the first occurrences of *Gnathodus texanus* at sample no. 91/49.

The succeeding rock sequence yielded a completely different conodont association which is dominated by gnathodids, e.g., *Gnathodus cuneiformis* and *G. punctatus*. Also, *G. semiglaber* and *G. praesemiglaber* occur frequently throughout the remaining part of the section but the ratio between these two species is rather constant.

The diagnostic characters of the name-bearer of the *texanus*-Zone, *Gnathodus texanus*, are well developed in some samples. In others, however, the main features are not so well recognizable. These specimens display characteristics of both *G. semiglaber* and *G. praesemiglaber* from which they have evolved by extreme narrowing of the cup and reduction or loss of the praeparapet to a single node (H.R. LANE et al., 1980). According to C.A. SANDBERG (1979) *G. texanus* is also very similar in the shape of the cup, ornamentation and the length of the parapet to *G. typicus* MT 2. The latter, however, is distinguished by its expanded posterior blade denticles (W. ZIEGLER, 1981).

In comparison with the range charts of H.R. LANE et al. (1980) and Z. BELKA (1985) the distribution of *Gnathodus punctatus* varies significantly in the Cima di Plotta section. According to H.R. LANE et al. (1980) *G. semiglaber* evolved from *G. punctatus* in the upper part of the *isosticha*-Upper *crenulata*-Zone by decreasing the size of the parapet and by reducing the ornamentation of the cup. Though we do not question this suggested phylogeny our material, however, clearly indicates a higher range of *G. punctatus* throughout most of the *texanus*-Zone. Supposedly it then gave rise to *G. praebilineatus* and, finally, to early representatives of *G. bilineatus*. Our range may thus confirm the data provided by A. VOGES (1959, 1960) and by D. MEISCHNER (1970) from the Rhenish region who both noted a range into the *anchoralis*-Zone and above, respectively.

To summarize, we regard the income of our assemblage 3 to approximate to the base of the *texanus*-Zone as defined by H.R. LANE et al. (1980). Generally, the base of this zone is regarded to correspond with the base of the Visean in the Belgian stratotype at Bastion (see "Introduction"). At the "Route de Salet" section, however, the first occurrence of *G. texanus* is far below this level at the base of the *anchoralis*-Zone (Z. BELKA & E. GROESSENS, 1986). In any way, our trilobite and goniatite fauna below bed no. 91/49 indicates the Pericyclus Stage cu IIγ.

The horizon with *Gnathodus praebilineatus* may either correspond to the upper portion of the *texanus*-Zone or to the "Unzoned Interval" of H.R. LANE et al. (1980) which is placed between the *texanus* and the following *bilineatus*-Zones. For the reasons presented in the paragraph 6 of the conodont biostratigraphy we favour a position in the higher part of the *texanus*-Zone.

The appearance of early representatives of *Gnathodus bilineatus* and of *Gnathodus girtyi* may either correspond to a high level of the *texanus*-Zone, the "Unzoned Interval", or the beginning of the *bilineatus*-Zone. Primarily this uncertainty is derived from the fact that any younger rocks are missing

which eventually contain more characteristic representatives of Gnathodus bilineatus.

Whether or not Gnathodus bilineatus appears gradually or suddenly has yet not been clearly demonstrated. According to D. MEISCHNER (1970) it evolved fairly suddenly shortly before the base of the Goniatites Stage in strata corresponding to cu IIδ. He also noted that this early occurrence is characterized by a rounded triangular outline of the cup. This feature applies as well to Gnathodus n.sp. A EBNER sensu S.-I. PARK (1983). Consequently, this species may be also regarded as an early representative of Gnathodus bilineatus. We are not able to recognize any objective difference between our occurrence of Gnathodus bilineatus, Gnathodus n.sp. A sensu S.-I. PARK (1983) and the supposed early representatives of Gnathodus bilineatus of D. MEISCHNER (1970) which we have not seen yet. If so, our specimens at hand belong to the same early occurring species Gnathodus bilineatus.

In conclusion, for the entrance of Gnathodus bilineatus and Gnathodus girtyi at the Cima di Plotta section it seems justified to consider a relative age close to or at the base of the standard bilineatus-Zone. In terms of the goniatite zonation, our uppermost limestone bed containing these conodonts suggests an age which corresponds to the Pericyclus Stage cu IIδ, or to the early Goniatites cu III Stage. According to E. GROESSENS (1977) in the Belgian Dinantian Gnathodus b. bilineatus appears in the Visean 3bβ, i.e., in the lower Warnantian.

6. The Tournaisian/Visean Boundary

As mentioned in the foregoing chapters and in the "Introduction" at the Cima di Plotta section there is no direct evidence for the precise recognition of the Tournaisian/Visean boundary. For the reasons presented above, however, we regard the base of the assemblage 3 which is characterized by Gnathodus cuneiformis, Gnathodus semiglaber, Gnathodus pseudosemiglaber and Gnathodus texanus to correspond with the stratotype for the Tournaisian/Visean boundary at Bastion section, Belgium (see E. GROESSENS & B. NOEL, 1977; R. CONIL et al., 1989; G.D. WEBSTER & E. GROESSENS, 1991). The inferred boundary is thus drawn at the base of sample bed 91/48, i.e. 3.20 m above the exposed Carboniferous limestone sequence. The remaining 3.84 m thick upper portion of the section belongs to the Visean. In terms of the Belgian terminology, it represents the Molinacian, Livian and basal Warnantian Stages.

7. Conodont Biofacies

In the Lower Carboniferous the lateral distribution of conodonts across the shallow carbonate shelf to the open sea and basinal environments follows a similar pattern as during the Late Devonian. The basic concept which is related to linear belts of regional tectonic settings was introduced by C.A. SANDBERG (1976) and later elaborated by C.A. SANDBERG & R. DREESEN (1984), 1987 and C.A. SANDBERG et al. (1988). Finally, C.A. SANDBERG & R.C. GUTSCHICK (1979, 1984) proposed a similar model for the distribution of conodonts of the Lower Carboniferous S. anchoralis-Zone which was updated by C.A. SANDBERG in H.R. LANE et al. (1980), H.R. LANE & W. ZIEGLER (1983) and P.H. v. BITTER et al. (1986). It was then applied to the British and the Belgian successions and their conodont faunas to ex-

plain the distinction between the shelf and basinal habitats (R.L. AUSTIN & R.B. DAVIES, 1984; R. DREESEN et al., 1986). Although a generally accepted biofacies model was not available for the Devonian/Carboniferous boundary, R.M.J. DREESEN (1992) used the combined data from the Late Devonian and the Lower Carboniferous to interpret the ratios of different conodont genera from the D/C boundary beds of the Carnic Alps.

The rich and diversified Lower Carboniferous conodont fauna of the Cima di Plotta section comprises more than 20.000 elements from 18 samples. Their distribution varies significantly throughout the section. With regard to the plots shown on Text-Fig. 6 it must be stated that ramiform elements were not counted.

The anchoralis/latus-Zone is characterized by 11 to 12 conodont taxa. Species of Gnathodus are most abundant followed by those of Scaliognathus and Polygnathus + Pseudopolygnathus. Less important are representatives of Bispathodus and Hindeodella segaformis being presumably an element of the apparatus of Scaliognathus. For details of the ratios between these genera we refer to Text-Fig. 6. In the uppermost sample 91/49 the dominance of Gnathodus is most evident: It exceeds Scaliognathus and Pseudopolygnathus + Polygnathus, respectively, by a factor of ten.

In the following sample 91/48 a drastic change of the conodont fauna occurs. We recognized four species of Gnathodus and one of Bispathodus. Representatives of the genera Pseudopolygnathus, Polygnathus and Scaliognathus completely disappeared. Apparently, this change coincides with the base of the anchoralis-bilineatus-Interregnum" of A. VOGES (1959, 1960), D. MEISCHNER (1970), and the extinction event of W. ZIEGLER & H.R. LANE (1987).

The remaining upper part of the section is equally characterized by two to six species of Gnathodus. Their high abundances contrast with rather insignificant occurrences of representatives of Vogelgnathus and Pseudopolygnathus + Polygnathus.

The distributional pattern of conodonts from Cima di Plotta section suggests living conditions in the middle or lower part of the aerobic zone at the shelf-edge, the slope, or other seaward environments of deposition. There is neither any faunal or rock evidence for a near-shore habitat on a carbonate platform nor any other restriction to a landward shallow water setting. The disappearance of the genera Scaliognathus and Doliognathus seems to be compensated in the higher portion of the section by a low-diversity conodont fauna which is dominated by representatives of Gnathodus. This genus too, characterized an off-shore environment. Hence, for deposition of the Kronhof Limestone of the Cima di Plotta section we conclude more or less stable conditions in an off-shore and moderately deep pelagic environment.

8. Implications and Conclusions

The main advantage of the Cima di Plotta section is its abundance in gnathodid conodonts. Different from other studies our conclusions are based on several hundreds if not more than 1000 representatives of Gnathodus in successive samples and thus enable a better understanding of the relationships between individual species of Gnathodus. In particular this regards the ancestorship of Gnathodus bilineatus which we believe is derived from Gnathodus punctatus in the upper texanus-Zone. Another contribution to the knowledge of Lower Carboniferous conodont research
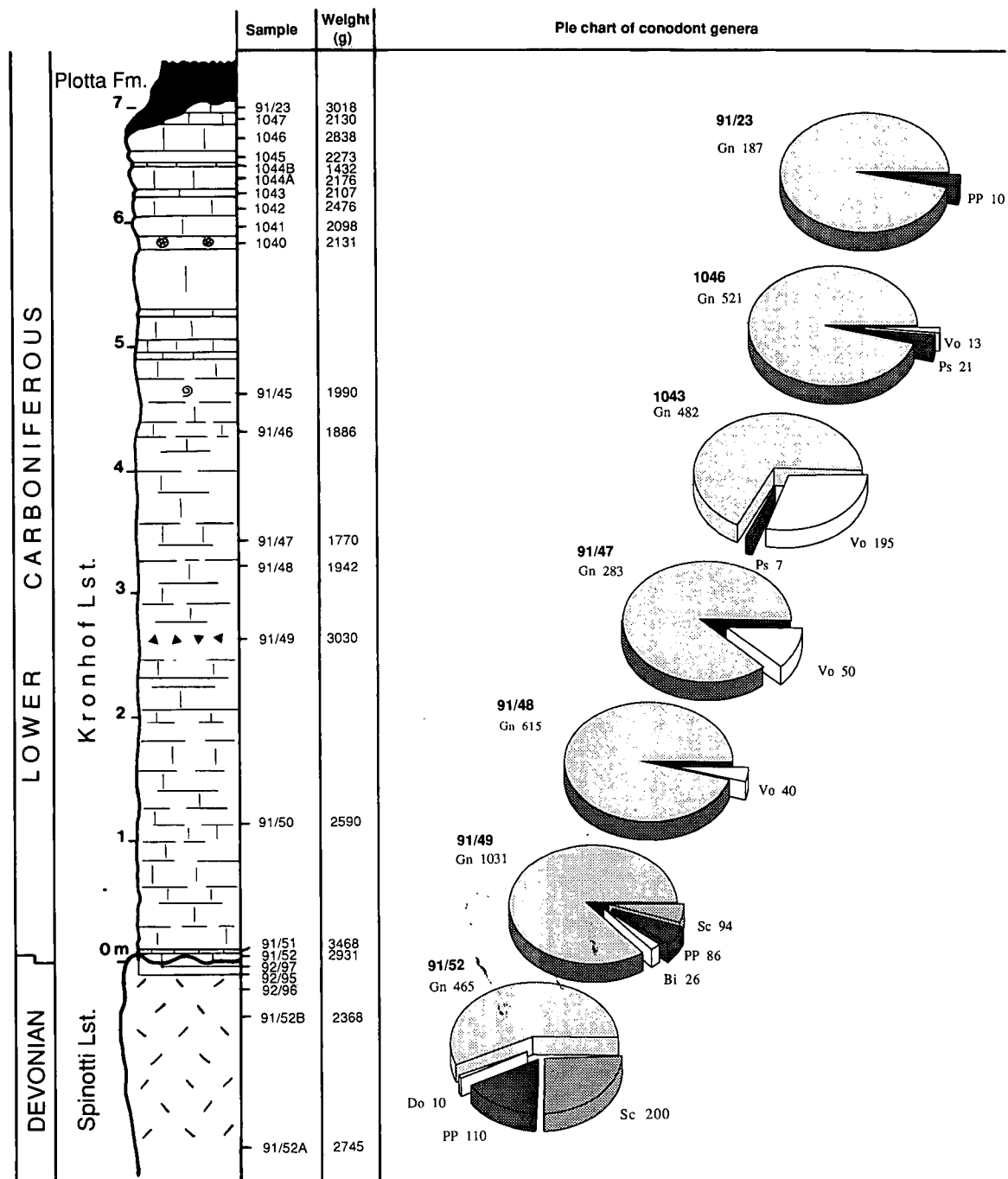
Text-Fig. 6.
Pie-chart of important conodont genera from selected samples of the Lower Carboniferous Kronhof Lst. of Cima di Plotta section.
Abbreviations: Do = *Doliognathus*; Sc = *Scaliognathus*; Bi = *Bispathodus*; Vo = *Vogelgnathus*; Gn = *Gnathodus*; Ps = *Pseudopolygnathus*; PP = *Polygnathus +
Pseudopolygnathus*.

concerns the upper range of the name bearer of the *an-choralis-latus*-Zone, i.e. *Scaliognathus anchoralis anchoralis* and the transition to conodont faunas of the following equivalent of the *texanus*-Zone. Our data confirm the conclusions drawn by H.R. LANE & W. ZIEGLER (1983) who demonstrated a phyletic lineage within the genus *Scaliognathus*. In our collection too, the nominate subspecies is the last occurring and most advanced form. Its upper range ended abruptly and there is no indication that the disappearance was controlled by the facies (see also W. ZIEGLER & H.R. LANE, 1987).

In terms of the current conodont zonation the Kronhof Limestone of Cima di Plotta section ranges from the "lower" *anchoralis-latus*-Zone to the end of the *texanus* or the

beginning of the *bilineatus*-Zone, respectively. Its lower part thus represents an equivalent of the Erdbach Lst. of the northeastern Rhenish Mountains. With regard to the goniatite succession the upper portion corresponds to the late Pericyclus Stage, or to the early Goniatites Stage, i.e., Lower Visean. In addition we emphasize that at Cima di Plotta section the youngest limestones of the whole Carnic Alps have yet been found which were formed prior to the deposition of the siliciclastic Hochwipfel Formation at the end of the Variscan sedimentary cycle.

The above described limestone sequence was intensively affected by a karstic event. This event was responsible for the distinct paleorelief that separates the lime-

255

stones from the overlying flysch deposits of the Hochwipfel Formation. In the surroundings of Cima di Plotta and on top of the section, the paleokarst is associated with an up to seven meter thick silcrete horizon, fissures, breccias and strata-bound ore deposits indicating sea-level lowering, erosion and reworking of rocks and faunas. Based on our new data the sequence of events which explain the variety of karst features must have occurred during the *texanus* or early *bilineatus*-Zone of the Lower Visean, and not during the *anchoralis-latus*-Zone as suggested by H.P. SCHÖNLAUB et al. (1991). It resulted in extensive limestone dissolution and karstification at the surface and the subsurface, formation of a high-porosity silcrete regolith, caves, cave sediments, speleothems, fissures and breccias. This short-term event was followed by a rise in sea-level which finally initiated the transgression of the Hochwipfel Formation not later than during the Middle Visean.

9. Paleontological Remarks and Systematics

The majority of taxa on which this study is based has already been dealt with in many other contributions on Lower Carboniferous conodonts. The following remarks are intended to draw attention to additional characteristic features of this fauna.

According to H.R. LANE et al. (1980) the diagnostic features of *Scaliognathus anchoralis anchoralis* are the platform-like lateral and anterior limbs, a reduced to absent posterior cusp and the small and usually triangular basal pit which may extend as narrow groove in the middle of the keele of the anterior limb. Beside other distinguishing features, the lower surface of its forerunners *S. a. europensis* and *S. a. angustilateralis* is characterized by large basal cavities. Our specimens at hand can be easily referred to the nominate subspecies. In few specimens, however, the lower surface does not exhibit the small basal pit as described and illustrated in the original diagnosis. Nevertheless we treat them as the nominate subspecies as they show all other characteristics, in particular the platform-like lateral extension of the limbs and a carina-like denticulation without a prominent posterior cusp.

The entrance of *Gnathodus texanus* is in sample no. 91/49 which contains the last index conodonts of the *anchoralis-latus*-Zone. In this and the following samples it is associated with *Gnathodus pseudosemiglaber*. In our collection there are only very few specimens which show the diagnostic features of this species, i.e. a single large node forming the parapet, the ornamentation of the outer cup by a single high node opposite to the pillar-like parapet and the short outer cup that terminates anterior of the posterior tip of the blade. Instead, in accordance with H.R. LANE et al. (1980) some of our representatives of *Gnathodus texanus* suggest transitional specimens that display characteristics of both *Gnathodus texanus* and *Gnathodus pseudosemiglaber* from which it may have evolved. We distinguished both species with regard to the pillar-like parapet instead of short and flat transverse ridges and the very short outer cup (see Pl. 5, Figs. 1–3). Also, we note a partial overlap between *Scaliognathus anchoralis anchoralis* and *Gnathodus texanus* and thus confirm the observations of H.R. LANE et al. (1980) at the Glenn Creek section, Arkansas.

In the Spanish Pyrenees *Gnathodus typicus* co-occurs fairly abundantly with *Scaliognathus anchoralis* but extends beyond the range of the latter (P. MARKS & H. WENSINK, 1970). This led the authors to establish a local and poorly defined partial range zone named *Gnathodus typicus* Zone. Though this species also occurs in the *texanus*-Zone of Cima di Plotta section in a supposedly comparable horizon we do not consider this species as an alternative index species of *Gnathodus texanus*. According to H.R. LANE et al. (1980) the *typicus*-Zone is placed much lower, namely between the *isosticha*-Upper *crenulata* and the *anchoralis-latus*-Zones.

From our uppermost sample 91/23 two distinct conodont taxa have been recovered which we believe to be more closely related to the *bilineatus* than to the *texanus*-Zone. As far as the outline of the cup, the extended parapet and the ornamentation of the outer cup are concerned, the first taxon (Pl. 6, Figs. 12–14) suggests early representatives of *Gnathodus bilineatus*. The main differences with the type material are the smaller outer cup and the shorter parapet. In general, we believe that the main features of *G. bilineatus* are already well although not fully developed. Since there are no objective differences between these specimens and *Gnathodus* n.sp. A EBNER sensu S.-I. PARK (1983) we regard them as conspecific; apparently, they have the same stratigraphic age at the end of the *texanus*-Zone. The second taxon shows the main characteristics of *Gnathodus girtyi*. Its common range with first appearances of *Gnathodus bilineatus* has been documented, for example from the borehole Velbert-4 in the Rhenish Mountains (S.-I. PARK, 1983, 1986).

Gnathodus praebilineatus
(Pl. 6, Figs. 7–11)

In our collection several gnathodid conodonts from sample nos. 1046 and 1047 resemble those representatives of *Gnathodus praebilineatus* BELKA which bear concentrically arranged rows of nodes on the outer cup (cf. Z. BELKA, 1985, Pl. 7, Fig. 8). This kind of ornamentation together with a short parapet also applies to morphotype 2 of *G. bilineatus* as recognized by A.C. HIGGINS & C.H.T. WAGNER-GENTIS (1982). Z. BELKA (1985) included such types into the new species *G. praebilineatus* which he regarded as immediate forerunner and hence, in an evolutionary relationship with *G. bilineatus bilineatus*.

Our representatives of *Gnathodus praebilineatus* are characterized by a rather broad asymmetric cup, an expanded posterior blade and a short parapet on the inner side, the anterior part of which bears short ridges or fused nodes. The large flat outer cup is covered by concentrically arranged nodes.

The parapet is restricted to the anterior part of the inner cup. Its shape varies to a certain extent: In some specimens it resembles a convex lobe with a curve on the inner side, in others it may be slightly curved with the concave side towards the blade. The nodes may either be fused and irregular or they form transverse ridges extending obliquely towards the carina. The larger outer cup bears nodose ornamentation, which is arranged in concentric rows paralleling the posterior margin of the outer cup. This part of the margin terminates anterior to the posterior end of the blade. The posterior blade denticles are widely expanded to form split denticles or short cross ridges. We believe this species evolved from *Gnathodus punctatus* with which it is connected by transitional forms; it gave rise to *Gnathodus bilineatus* by extension of the parapet, and enlargement and flattening of the outer cup. We thus do not agree with Z. BELKA (1985) who regarded *G. semiglaber* as the probable ancestor.

256

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Plate 1

Fig. 1: **Pelagic mudstone.**
Note stylolitic seam across the slide. The faint and irregularly distributed white spots represent quartz derived from the overlying silcrete of the Plotta Formation.
Cima di Plotta section, sample 1047, Kronhof Lst., uppermost limestone bed underlying Plotta Formation (silcrete); *texanus*-Zone. ×7.5.

Fig. 2: **Bioclastic mud-/wackestone.**
Pelagic cephalopod limestone.
Cima di Plotta section, sample 1046, Kronhof Lst.; *texanus*-Zone. ×7.5.

Fig. 3: **Pelagic bioclastic wackestone.**
The middle part of the photomicrograph is characterized by a detrital layer composed of cephalopod shells and trilobite remains. Other biodetritus represents small ostracod shells. The matrix is partly recrystallized.
Cima di Plotta section, sample 91/46, Kronhof Lst., *texanus*-Zone; ×7.5.

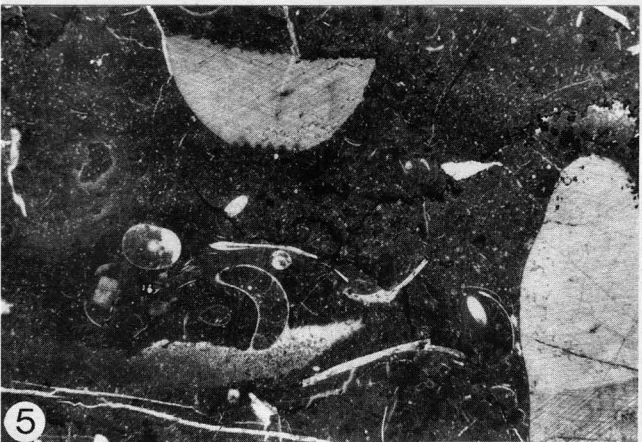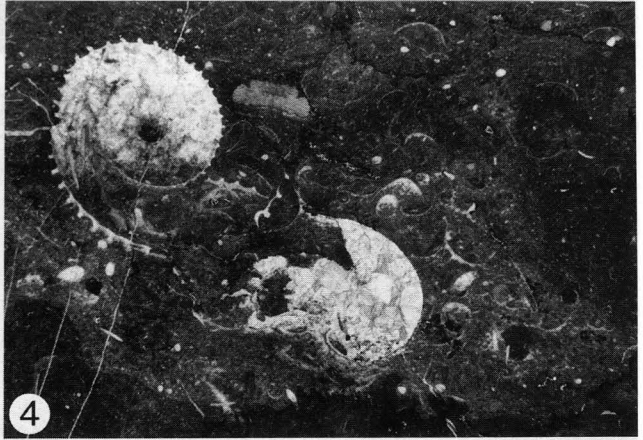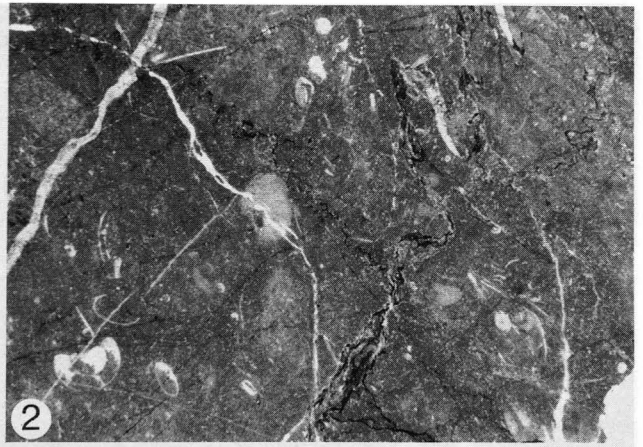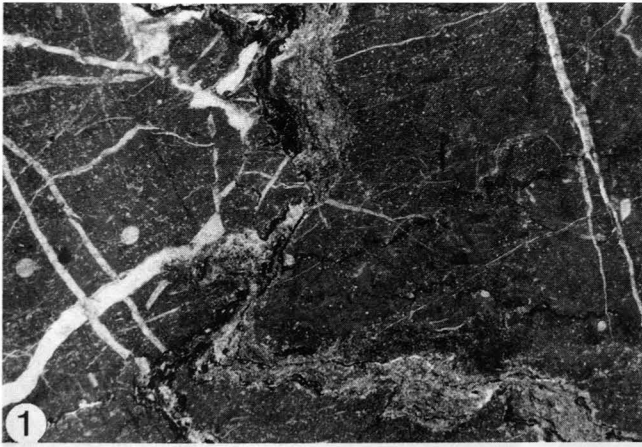Fig. 4: **Cephalopods in a bioclastic wackestone.**
Cross sections of ornamented cephalopod shells within a pelagic limestone. Note fossil spirit level.
Cima di Plotta section, sample 91/48, Kronhof Lst., *texanus*-Zone; ×7.5.

Fig. 5: **Bioclastic wacke-/floatstone.**
Large echinoderm fragments floating in the pelagic cephalopod limestone. The input of this debris suggests a shallow water source area. Note bioturbation structure below the half-moon like cross section of the cephalopod shell which functioned as a shelter. Later it was filled by coarse-grained sediment.
Cima di Plotta section, sample 91/49, *anchoralis*-Zone; ×7.5.

Fig. 6: **Bioclastic wackestone.**
Cephalopods, filaments and shell fragments are present. An echinodermal fragment is surrounded by an algal crust (right margin).
Cima di Plotta section, sample 91/52, Kronhof Lst., lowermost sample immediately above the disconformity surface, *anchoralis-Zone*; ×6.

258

Plate 2

Fig. 1: **Mud-/wackestone.**
4 cm thick laminated limestone bed composed of mainly rounded intraclasts. Note pressure effects causing thin solution planes.
Cima di Plotta section, sample 91/51, Kronhof Lst., second bed of the Lower Carboniferous sequence; *anchoralis*-Zone. ×26.

Fig. 2: *Amphipora* **sp., embedded in a coated-grain limestone.**
The grainstone shows birdseye structure. The majority of the grains are coated grains, peloids and few onkoids (black grains at the bottom). Due to recrystallization the amphiporids are undeterminable.
Cima di Plotta section, sample 92/96, Spinotti Lst., Givetian (or early Frasnian); ×7.5.

Fig. 3: **Longitudinal section of** *Amphipora* **sp.**
The amphiporid sections (longitudinal and cross) show calcitic envelopes caused by algal activity. Below the dark grain an algal lump is situated.
Cima di Plotta sec; ×6.

Fig. 4: **Coated-grain lime/grainstone with amphiporids.**
Cima di Plotta section, sample 91/54 (2 m below sample no. 91/53), Spinotti Limestone, Givetian; ×5.25.

Fig. 5: **Coated-grain lime/grainstone with amphiporids with graded bedding.**
Amphipora rudis (at lower right portion of the photomicrograph) is surrounded by algal crusts. This lower part is more coarse-grained than the upper portion suggesting decreased water energy.
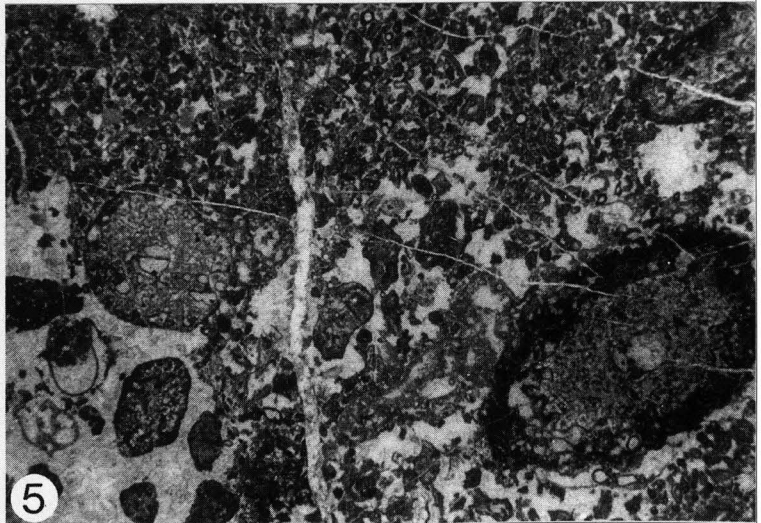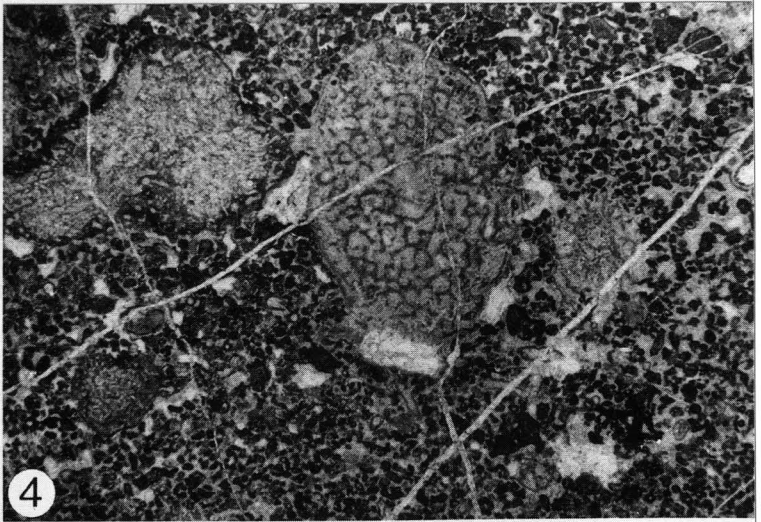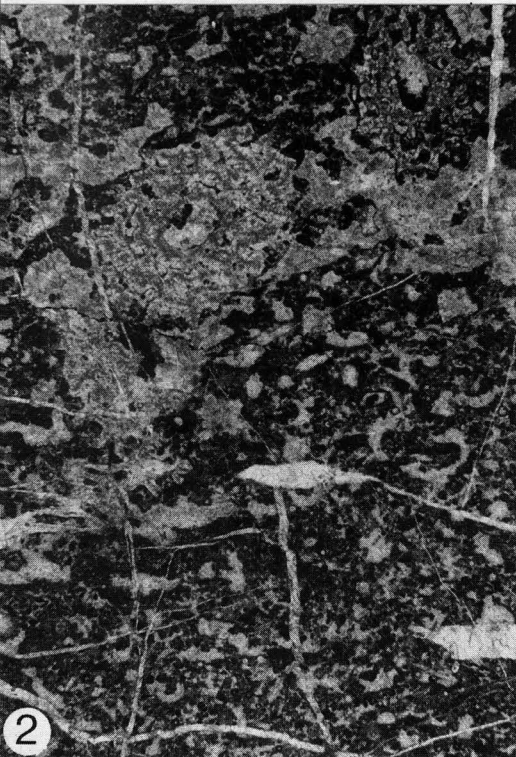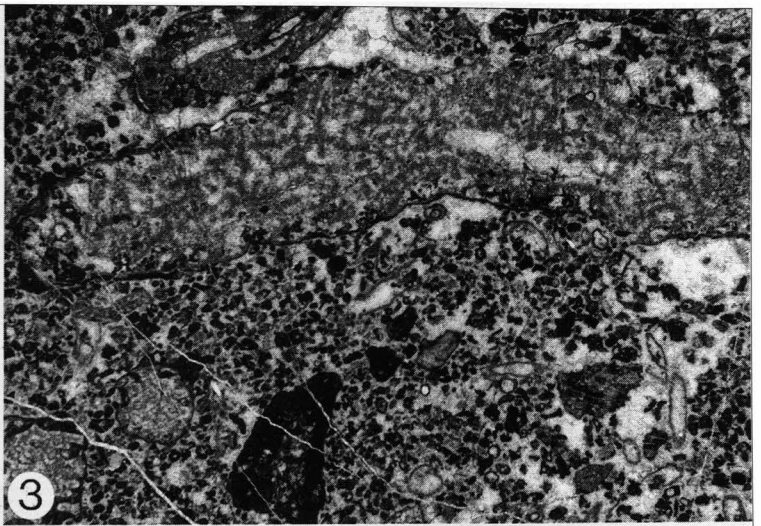Cima di Plotta section, sample 91/56 (13 m below the unconformity), Givetian (or early Frasnian); ×7.5.
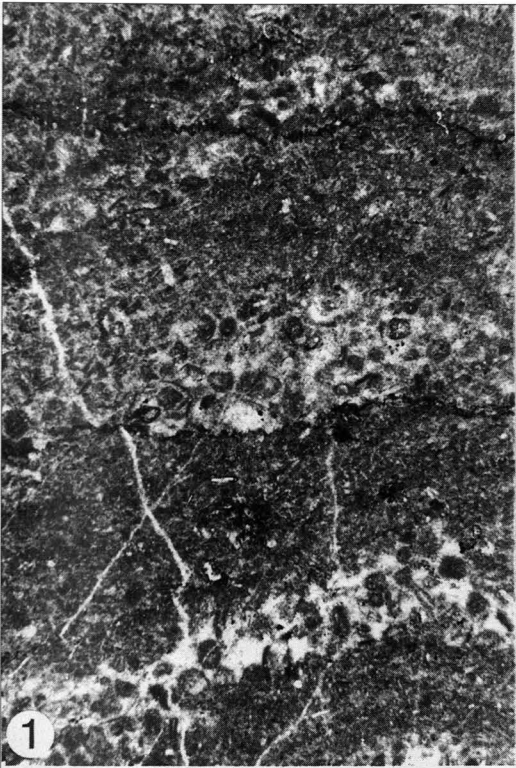
Figs. 1– 3: *Doliognathus latus* BRANSON & MEHL.
Figs. 1,2: Sample 91/52; ×52, ×83.
Fig. 3:   Sample 91/51; ×126.

Fig.   4:   *Dollymae* cf. *hassi* VOGES.
Sample 91/51; ×114

Fig.   5:   *Hindeodella segaformis* BISCHOFF.
Sample 91/52.; ×72.

Fig.   6:   *Scaliognathus praeanchoralis* LANE, SANDBERG & ZIEGLER ?
Sample 91/52.; ×55.

Figs.   7–10: *Scaliognathus angustilateralis* HIGGINS.
Sample 91/52; ×55, ×43, ×58, ×70.

Figs. 11–15: *Scaliognathus anchoralis europensis* LANE & ZIEGLER.
Figs. 11–12: Sample 91/52; ×58, ×45.
Figs. 13–15: Sample 91/49 (Fig. 15 enlargement of oral surface of plate); ×59, ×50, ×800.

Figs. 16–18: *Scaliognathus anchoralis anchoralis* BRANSON & MEHL.
Sample 91/50; ×39, ×48, ×48.
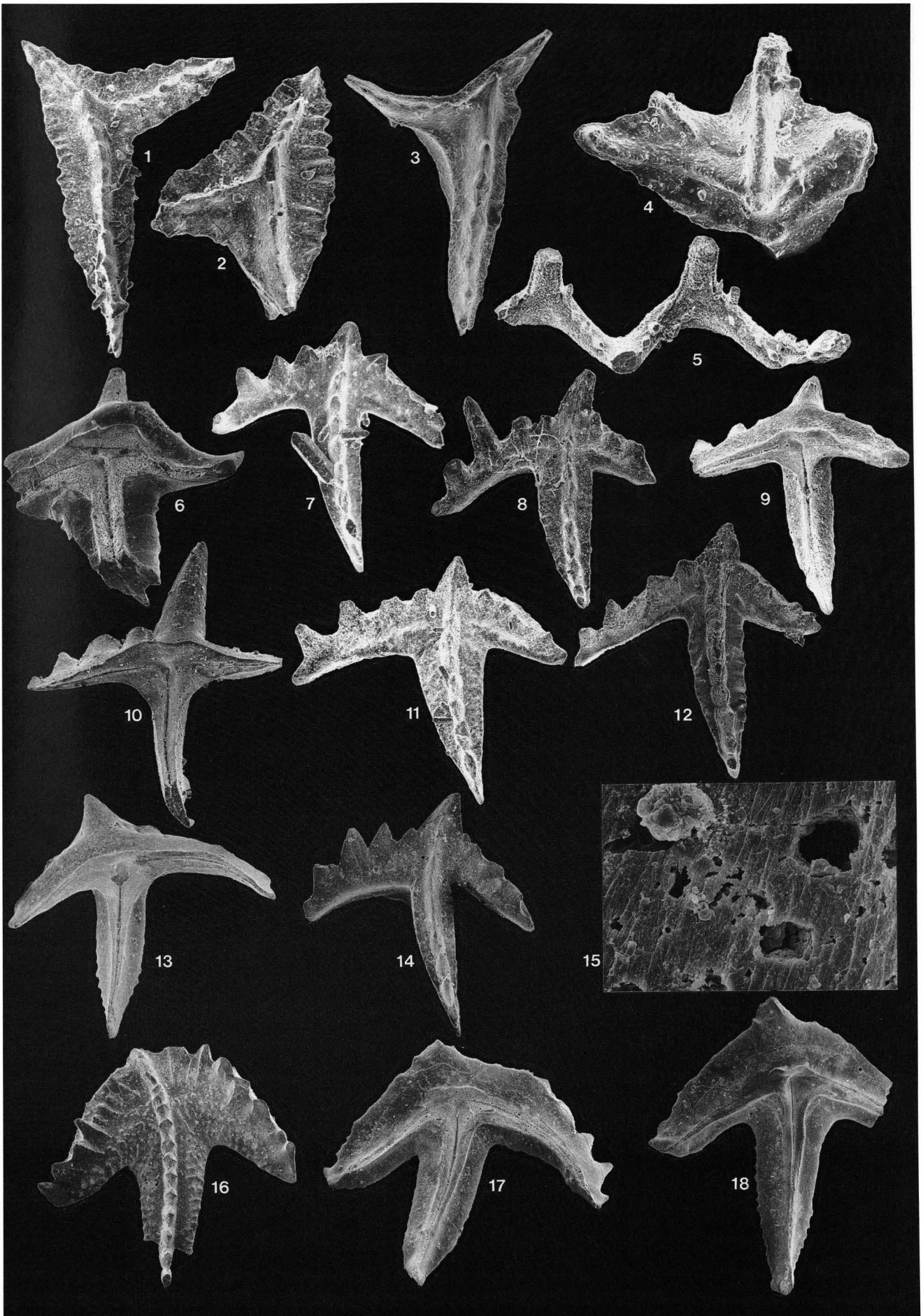
Figs. 1–3:   **Gnathodus cordiformis LANE, SANDBERG & ZIEGLER.**
Fig. 1:   Sample 91/51; ×72.
Figs. 2,3: Sample 91/52; ×58, ×59.

Figs. 4–9,16:   **Gnathodus delicatus BRANSON & MEHL.**
Figs. 4,5: Sample 91/52; ×71, ×86.
Fig. 6:   Sample 1041; ×83.
Figs. 7,8: Sample 91/48; ×52, ×53.
Fig. 9:   Sample 91/51; ×65.
Fig. 16:   Sample 1041; ×68.

Figs. 10–15,18–22: **Gnathodus punctatus (COOPER).**
Figs. 10,11:   Sample 1046; ×36, ×75.
Figs. 12–14,20: Sample 91/47; ×58, ×55, ×55, ×52.
Figs. 15,19:   Sample 1045; ×54, ×36.
Figs. 18,22:   Sample 1044 A; ×70, × 88.
Fig. 21:   Sample 1041; ×76.

Fig. 17:   **Gnathodus delicatus – Gnathodus punctatus transition.**
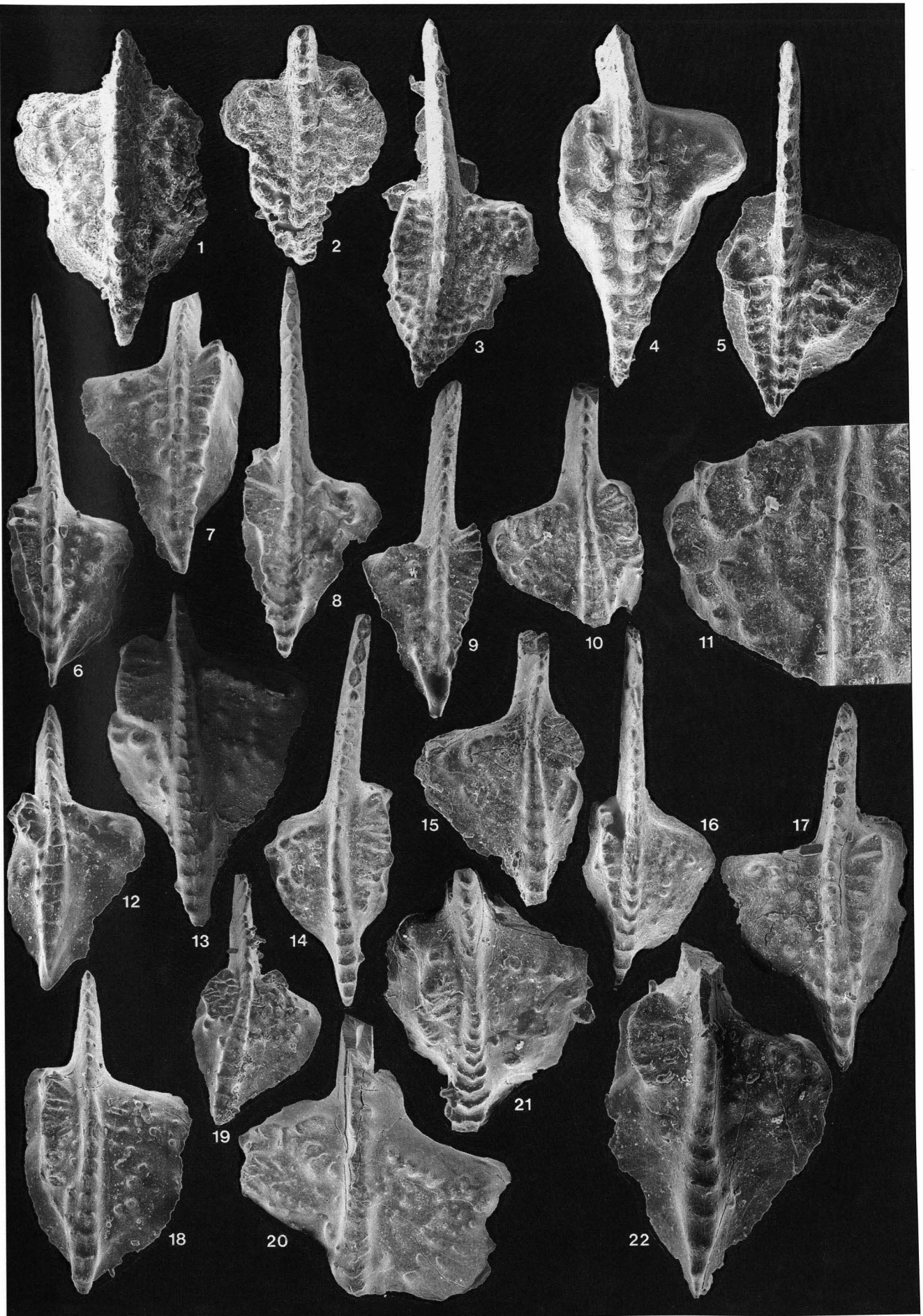Sample 1042; ×68.

264

Plate 5

Figs. 1– 3:   *Gnathodus texanus* ROUNDY.
                 Sample 91/49; ×72, ×78, ×43.

Figs. 4–8:   *Gnathodus typicus* COOPER.
                 Figs. 4,5,7: Sample 91/47; ×69, ×87, ×87.
                 Figs. 6,8:   Sample 91/50; ×96, ×83.

Figs. 9–15,21:   *Gnathodus cuneiformis* MEHL & THOMAS.
                 Fig. 9:   Sample 91/47; ×72.
                 Figs. 10,12,14,15: Sample 91/ 50; ×68, ×69, ×54, ×78.
                 Figs. 11,13,21:   Sample 91/48; ×58, ×49, ×43.

Figs. 16–20,22–26: *Gnathodus semiglaber* BISCHOFF.
                 Figs. 16,23:   Sample 1046; ×65, ×50.
                 Fig. 17:   Sample 1044 B; ×70.
                 Figs. 18,26:   Sample 91/48; ×51, ×44.
                 Figs. 19,20,25: Sample 91/49; ×44, ×46, ×52.
                 Figs. 22,24:   Sample 1043; ×54, ×50.
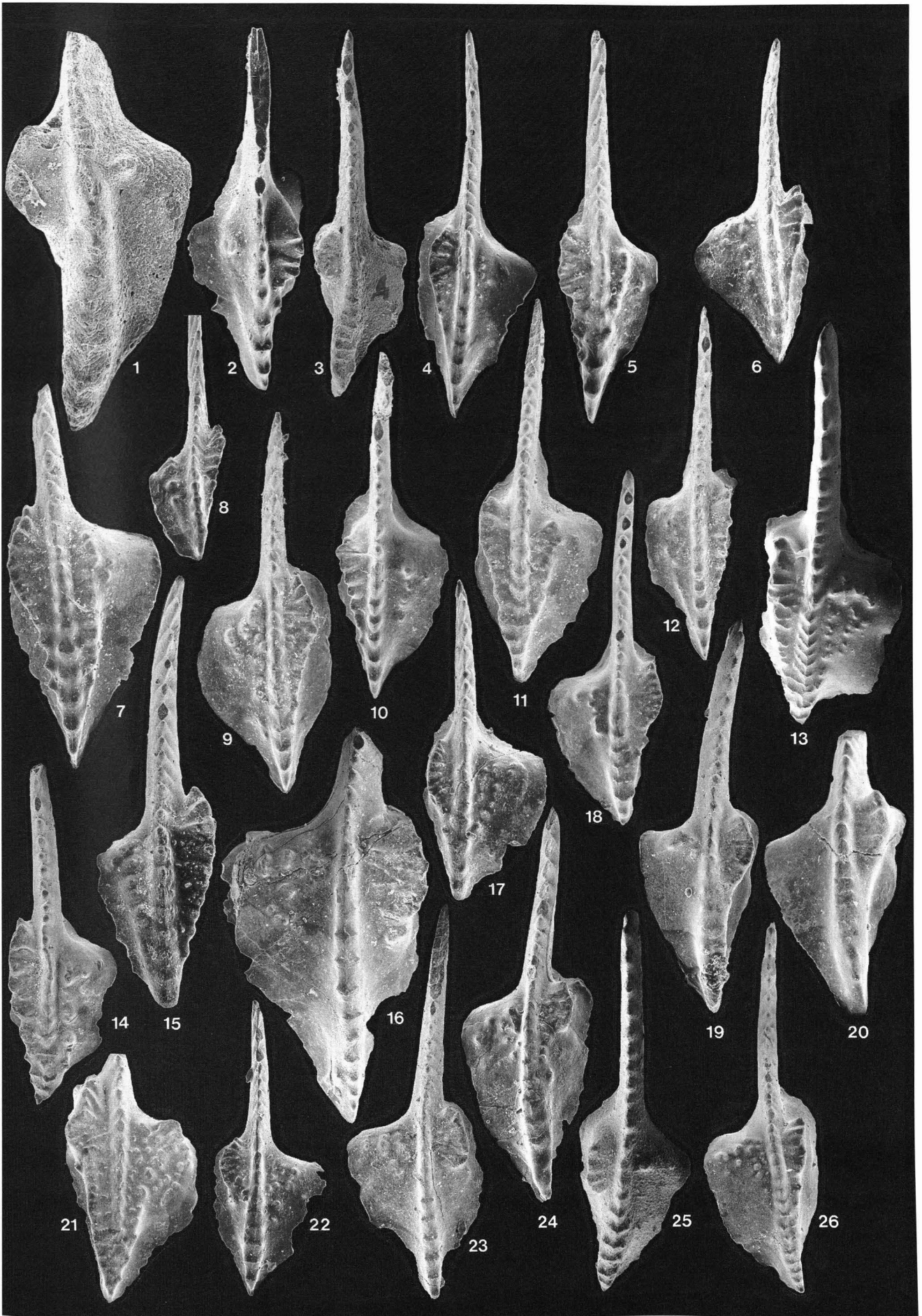
266

Plate 6

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Figs. 1– 6: **Gnathodus pseudosemiglaber** THOMPSON & FELLOWS.
        Fig. 1: Sample 1046; ×71.
        Figs. 2,6: Sample 91/49; ×52, ×46.
        Fig. 3: Sample 91/50; ×45.
        Fig. 4: Sample 1047; ×63.
        Fig. 5: Sample 91/47; ×49.

Figs. 7–11: **Gnathodus praebilineatus** BELKA.
        Figs. 7– 9: Sample 1047; ×80, ×55, ×64.
        Figs. 10–11: Sample 1046; ×70, ×63.

Figs. 12–14: **Gnathodus bilineatus bilineatus** (ROUNDY) – (early representatives).
        Sample 91/23; ×69, ×88, ×110.

Figs. 15,16: **Gnathodus girtyi** HASS.
        Sample 91/23; ×100, ×122.

Fig. 17: **Polygnathus bischoffi** RHODES, AUSTIN & DRUCE.
        Sample 91/50; ×57.

Fig. 18: **Pseudopolygnathus oxypageus** LANE, SANDBERG & ZIEGLER.
        Sample 91/51; ×88.

Fig. 19: **Vogelgnathus campbelli** (REXROAD).
        Sample 91/47; ×122.

Figs. 20, 21: **Pseudopolygnathus pinnatus** (VOGES).
        Fig. 20: Sample 91/47; ×54.
        Fig. 21: Sample 91/49; ×70.