Field Trip C

CONODONT LOCALITIES IN THE SURROUNDINGS OF GRAZ/STYRIA

By

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11 figures, 8 tables and plates 15–16

A contribution to Project „Prevariscic and Variscic Events of the alpine mediterranean mountain belts"

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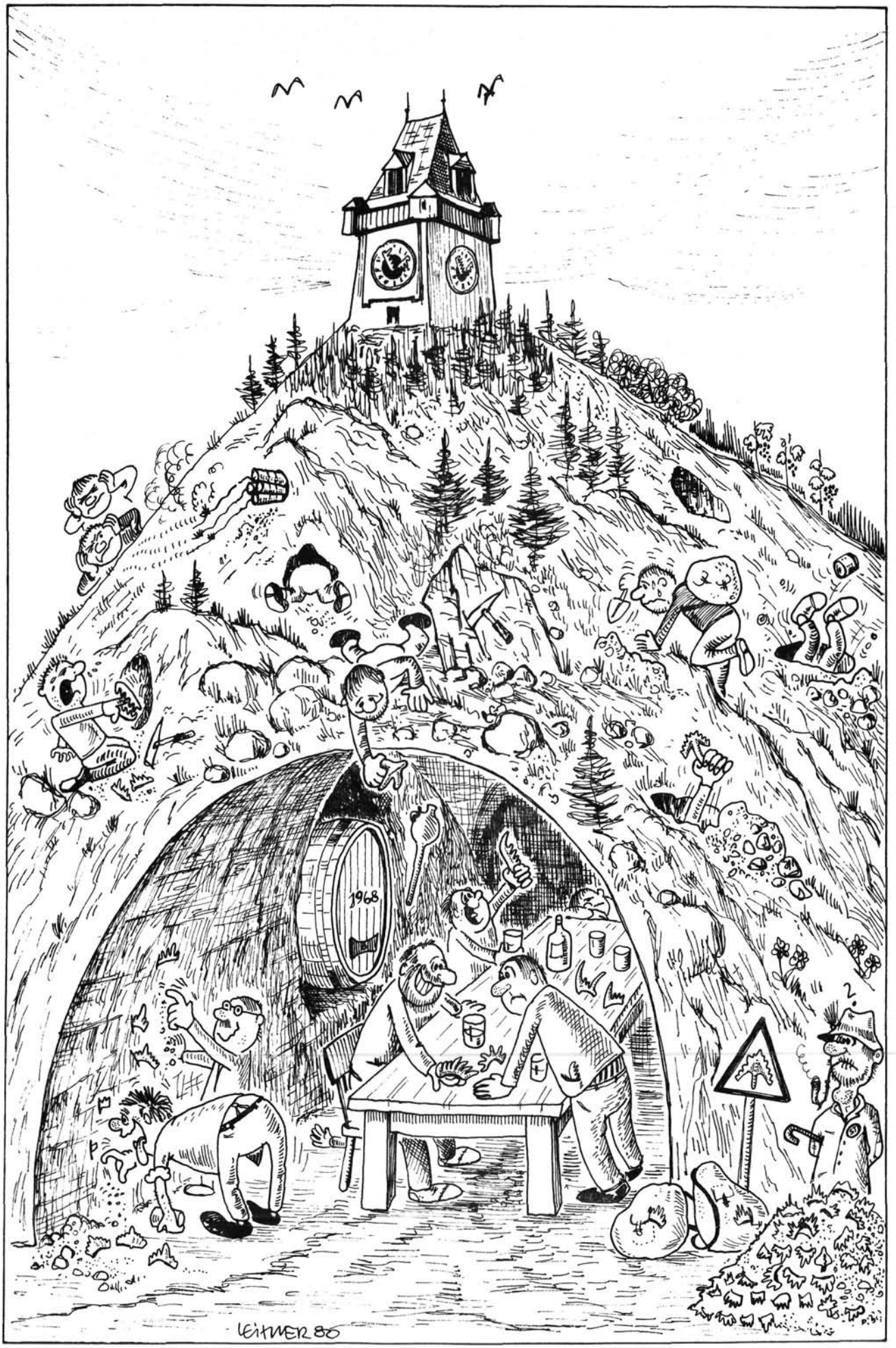
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Introduction

The Paleozoic outcrops in the surroundings of Graz (approx. 1000 km²) are part of the Upper Austroalpine nappe system. It rests tectonically upon a crystalline basement („Altkristallin") and its Mesozoic (?) cover. Parts of the Graz Paleozoic are overlain by Upper Cretaceous sediments, the so-called „Kainach Gosau", and towards the south-east by Tertiary deposits of the Styrian Basin. Structurally, it is characterized by nappes of probably alpine origin.

According to H. W. FLÜGEL 1972 the Graz Paleozoic can be divided into three facies realms (fig.1):

1. Rannach facies
2. Hochlantsch facies
3. Tonschiefer facies (Schöckel Lst. facies).

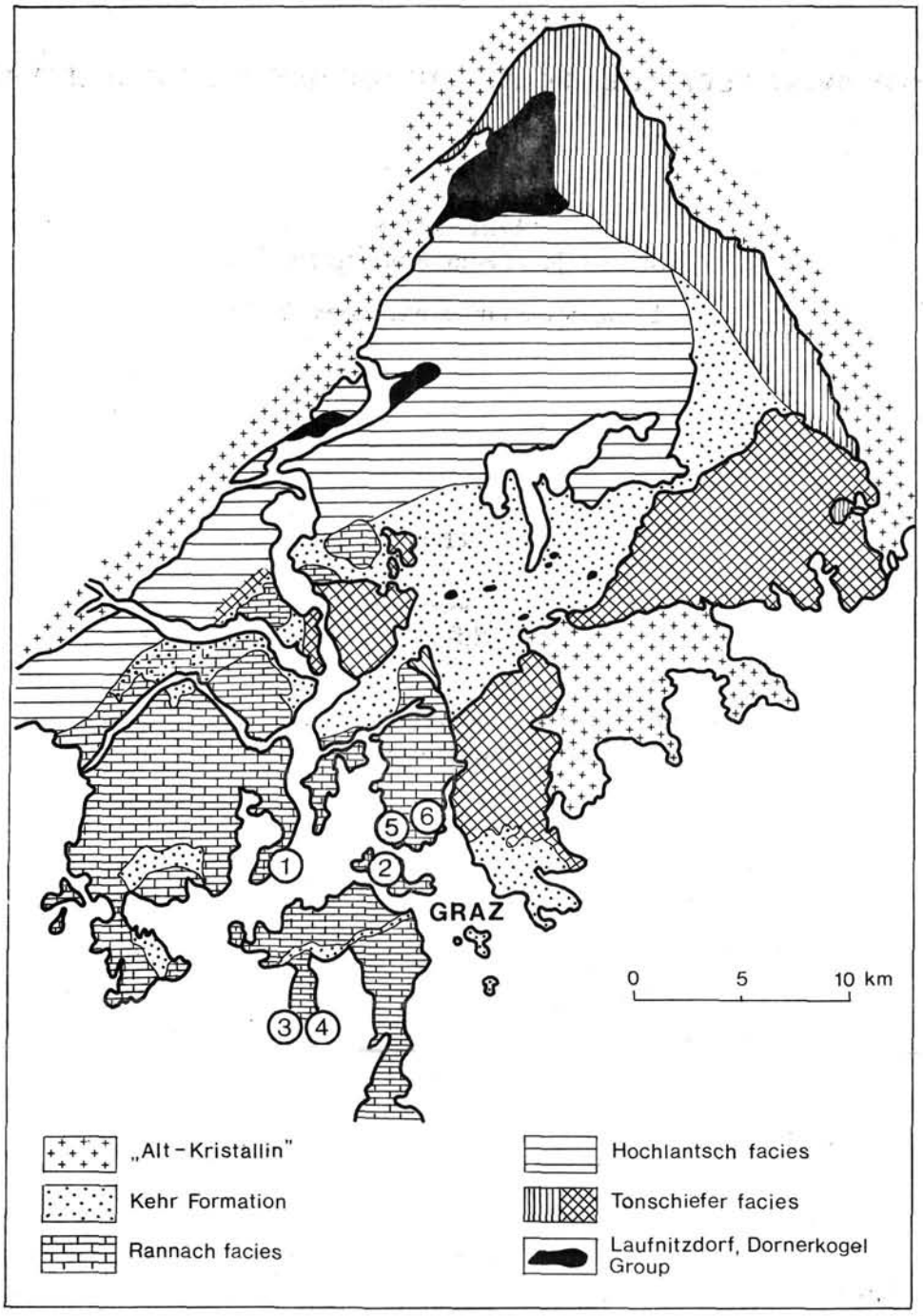


Fig. 1: Facies distribution of the Graz Paleozoic (H. W. FLÜGEL 1972). Numbers indicate stops during ECOS II-field trip C.

An additional but stratigraphycally less well defined facies is known around Laufnitzdorf and Breitenau („Dornerkogel Group"), north of Frohnleiten.

Rannach- and Hochlantsch facies temporarily represent shallow water deposits and thus contrast with the Tonschiefer facies interpreted as basin sediments.

The fundamental framework of Paleozoic stratigraphy within the Eastern Alps has first been established in the vicinity of Graz. The geologic history dates back to 1828 when M. ANKER recognized the „Übergangsgebirge" (= transition zone) of G. A. WERNER. F. UNGER 1843 discovered fossils which he compared with Devonian faunas from the Eifelian hills and the Harz Mt.; G. STACHE and K. A. PENECKE successfully subdivided the rock sequence by means of fossils and established a first biostratigraphic scheme.

Graz is also the place where F. HERITSCH lived and lectured as Head of the Department of Geology at the University. He intensively studied coral and brachiopod faunas which were derived from the

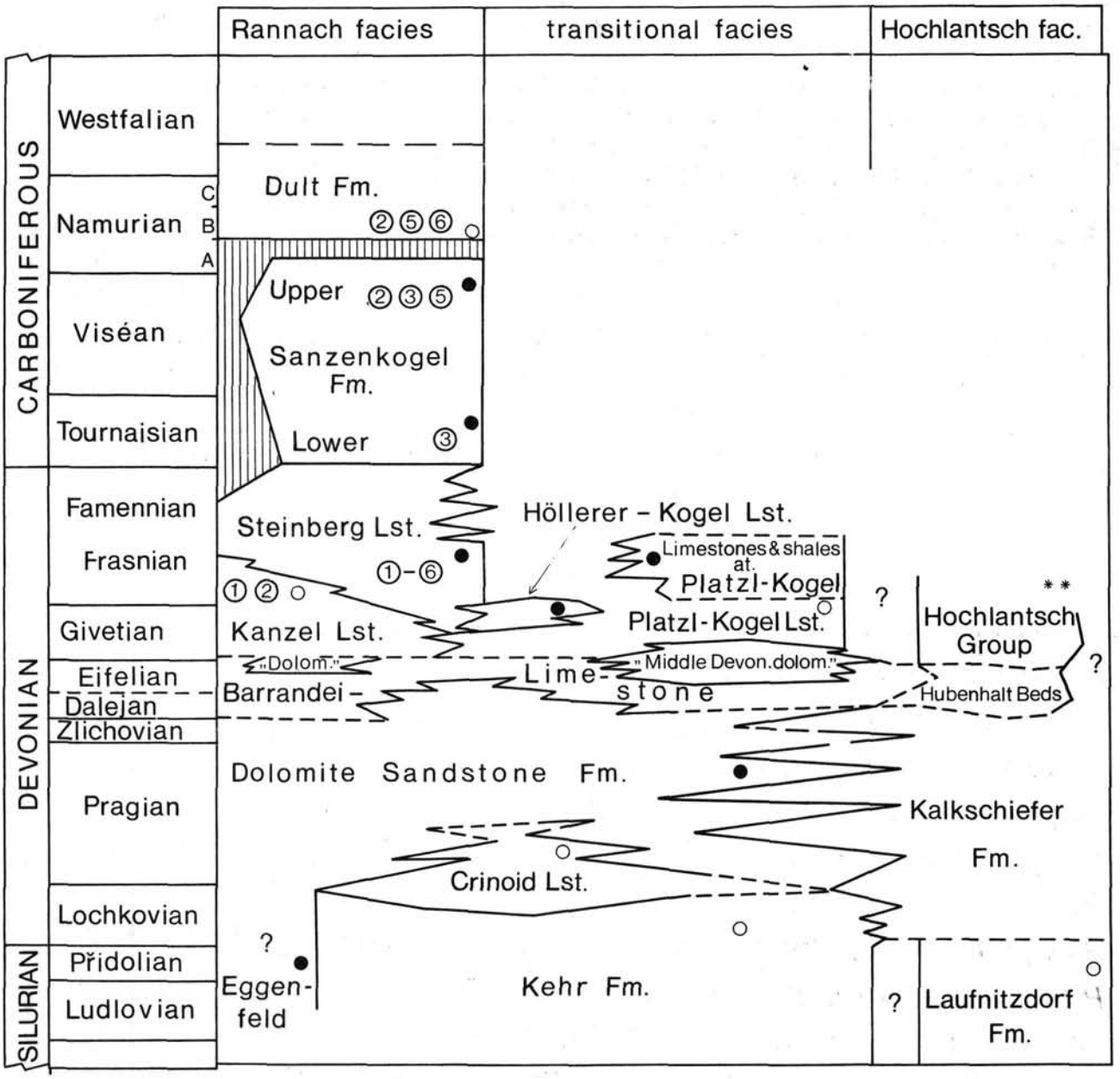


Fig. 2: Stratigraphy of conodont bearing sequences in the Graz Paleozoic (F. EBNER et al. 1979). Note that the relation of the Silurian sequence at Eggenfeld and the Laufnitzdorf Fm. with regard to the Rannach facies realm and the Hochlantsch facies realm respectively have not been solved yet.
Studies in progress; conodonts can be expected from various levels
● moderate or rich abundance of conodonts
o low frequency of conodonts and bad preservation respectively
1–6 vertical range of the sections visited.

fossiliferous Middle Devonian limestones. His results are compiled in „Stratigraphie der geologischen Formationen der Ostalpen" published in a few copies in 1943.

After World War Two study of lithology and fossils continued, this time by H. W. FLÜGEL and his students. In the fifties conodont research was initiated in the Eastern Alps by H. W. FLÜGEL and W. ZIEGLER by a study of the Upper Devonian Steinberg Lst. (1957). Conodont activities proceeded in the following years but were concentrated on limestones of Upper Devonian and Lower Carboniferous ages within the Rannach facies (A. KHOSROVI-SAID 1962, G. FLAJS 1966, M. G. KODSI 1967, L. NÖSSING 1974 a, b, 1975, L. NÖSSING, F. EBNER & H. W. FLÜGEL 1977, R. SURENIAN 1978, F. EBNER 1976 a, 1977 a, b, 1978, M. F. BUCHROITHNER 1979).

The youngest strata of the Rannach facies comprise a shale and limestone formation, known as Dult Fm. Very recently, its Upper Carboniferous age has been proved by conodonts (F. EBNER 1975, 1976 a, 1977 a, b, 1978).

To a lesser extent conodont research has been carried out in older rocks, although Upper Silurian and Lower Devonian conodont faunas have been described from various localities in the Rannach facies, from Laufnitzdorf, and from Eggenfeld (O. H. WALLISER in H. W. FLÜGEL 1961, O. H. WALLISER 1964, H. W. FLÜGEL & H. P. SCHÖNLAUB 1971, F. EBNER 1976 b, F. EBNER et al. 1979).

In recent years additional conodont data have been derived from Lower Devonian limestones which represent the transition from the Rannach facies to the Hochlantsch facies (M. F. BUCHROITHNER 1978, H. P. SCHÖNLAUB 1979, F. EBNER et al. 1979). Conodont information from the latter, however, is generally poor and, for example, comes mainly from Upper Devonian limestones.

The conodont bearing horizons in the Paleozoic rocks around Graz are shown in fig. 2.

	lower *varcus* – Zone	*hermanni* – *cristatus* – Zone
Icriodus brevis STAUFFER	×	
Polygnathus cristatus HINDE		×
Polygnathus decorosus STAUFFER		×
Polygnathus dubius HINDE		×
Polygnathus cf. *latifossatus* WIRTH	×	
Polygnathus linguiformis linguif. ♂, ♂, ♀ - MT	×	
Polygnathus linguiformis parawebbi CHATTERTON		×
Polygnathus ovatinodosus KLAPPER & ZIEGLER		×
Polygnathus pseudofoliatus WITTEKIND	×	×
Polygnathus timorensis KLAPPER, PHILIP & JACKSON	×	×
Polygnathus varcus STAUFFER	×	
Schmidtognathus hermanni ZIEGLER		×

Tab. 1: Conodonts from the upper part of the Kanzel Lst.

1. Rannach facies

Within this facies conodonts are known which span the time from Upper Silurian to the Namurian/Westfalian boundary level. To a great degree occurrences and abundance of conodonts are facies controlled.

The oldest formation of the Rannach facies, the Kehr Fm., comprises a 500 m thick sequence of shales/slates, sandstones and basic volcanites dominating the lower part („Untere Schichten von Kehr"), and a shaly-calcareous upper part („Obere Schichten von Kehr"). Conodonts are very rare. They were found in limestone lenses belonging to the upper part. The following conodont zones have been proved by H. W. FLÜGEL & H. P. SCHÖNLAUB 1970 and F. EBNER et al. 1979:

ploeckensis-Zone:
Oz. exc. inflata (WALLISER)

siluricus-latialata-Zone:
Oz. ziegleri WALLISER
Oz. cf. *jaegeri* WALLISER

Lochkov:
Oz. incl. wurmi (BISCHOFF & SANNEMANN)
Oz. r. remscheidensis (WALLISER)
Sagittodontus cf. *thuringicus* JENTZSCH

The Kehr Fm. is overlain by the 100 m thick Crinoid Fm. This formation includes different types of limestones, e. g., platy limestones, marly limestones, Flaser limestones and crinoidal limestones. So far, only *Pandorinellina optima* (MOSKALENKO) has been found indicating a late Lochkovian age (H. P. SCHÖNLAUB in H. W. FLÜGEL 1975).

The Crinoid Fm. is succeeded by the 1000 m thick Dolomite-Sandstone Fm. which apparently reflects a peritidal environment with temporarily changing coast lines, sand barriers and small lagoons (A. FENNINGER & H. L. HOLZER 1979). Yet, conodonts have only been found in normal marine contemporaneous deposits of the transitional facies.

The Dolomite-Sandstone Fm. is followed by a thick shallow water limestone sequence, i. e., the fossiliferous Barrandei Fm. of Eifelian age and the Kanzel Lst., which ranges from the Givetian to Frasnian. So far, only the Kanzel Lst. yielded stratigraphically important conodonts (M. F. BUCHROITHNER 1979). They belong to the lower *varcus*-Zone and the *hermanni-cristatus*-Zone (tab. 1).

The shallow water limestones of the Kanzel Lst. are diachronously succeeded by nodular cephalopod limestones. Locally, this pelagic environment lasted through the whole Upper Devonian, the Lower Carboniferous, and parts of the Namurian stage (E_2).

Due to a significant facies break between Kanzel Lst. and Steinberg Lst. above the exact position of the Middle/Upper Devonian boundary has yet not been drawn satisfactorily. G. FLAJS who studied the presumed boundary level in great detail in a quarry (1966) did not recognize the *hermanni-cristatus*-fauna. Unfortunately, this section has been destroyed a few years ago.

The cephalopod limestones on top of the Kanzel Lst. are subdivided into the 20–70 m thick Upper Devonian Steinberg Lst. and the 25 m thick Carboniferous Sanzenkogel Fm. Although this succession is conformable, locally a distinct disconformity with stratigraphic gaps, karst phenomena and reworked conodonts can be observed. Generally, the hiatus increases towards the east. For example, F. EBNER 1978 reported from here a gap from doII/III up to cuII/III. Contrary, in more western regions continuous sections across the Devonian/Carboniferous boundary have been proved.

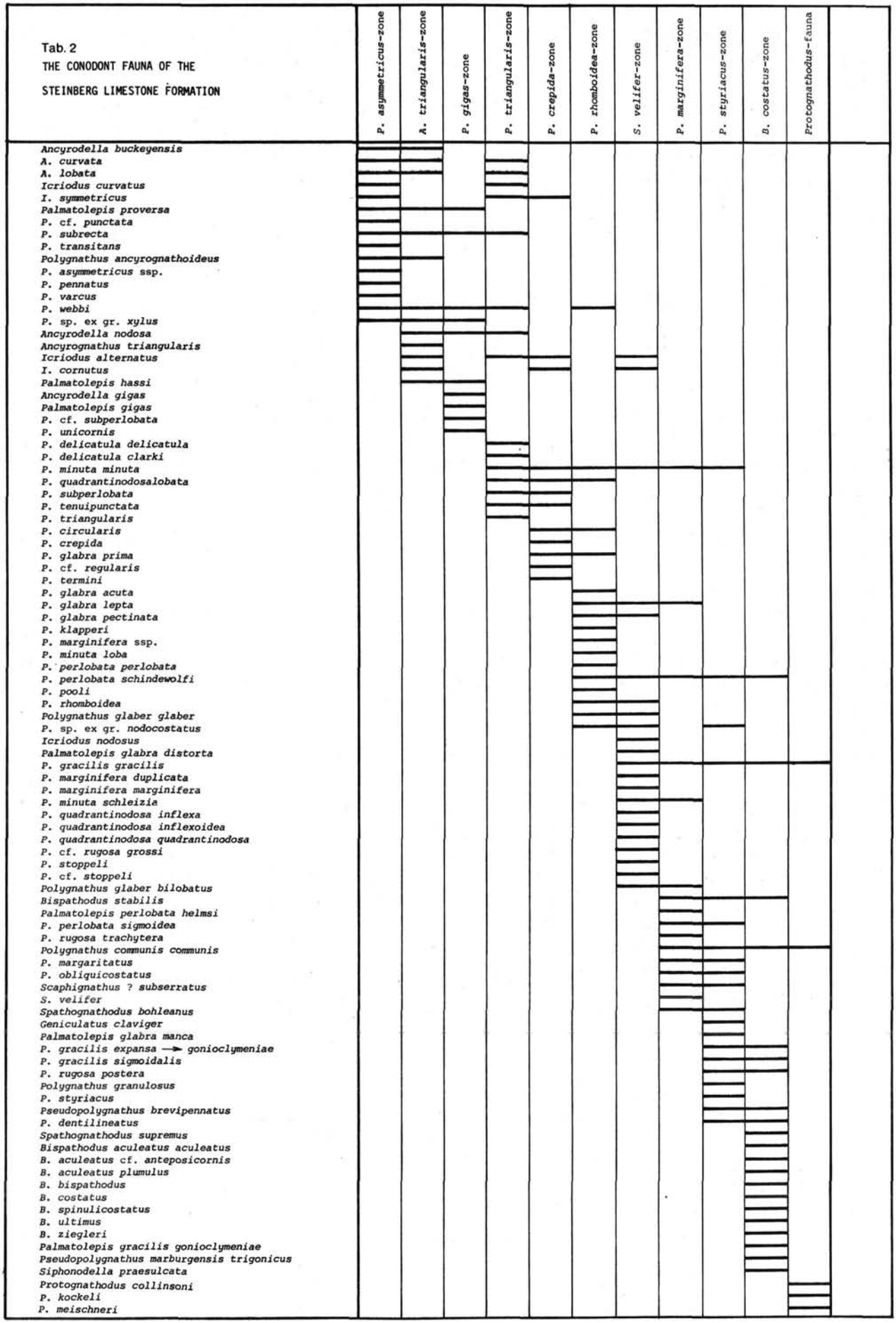
Studies of the microfacies and the fauna, geochemical analysis, and the occurrences of phosphatic nodules suggest that both the Steinberg Lst. and Sanzenkogel Fm. may have been deposited in depths between 60 and 300 m.

According to M. F. BUCHROITHNER et al. 1979 the thicknesses of individual Upper Devonian conodont zones depend on the amount of condensation and thus vary considerably. A list of conodonts from the Steinberg Lst. at its type locality has been published by R. SURENIAN 1978. Table 2 is based on these data as well as on new information from section „Weihermühle" which both will be visited during the field trip.

The Sanzenkogel Fm. can be subdivided into a lower member („Untere Sanzenkogel-Schichten") and an upper member („Obere Sanzenkogel-Schichten"). The first one, best exposed at Trolp Quarry reaches a thickness of 3,2 m, the latter approx. 22 m.

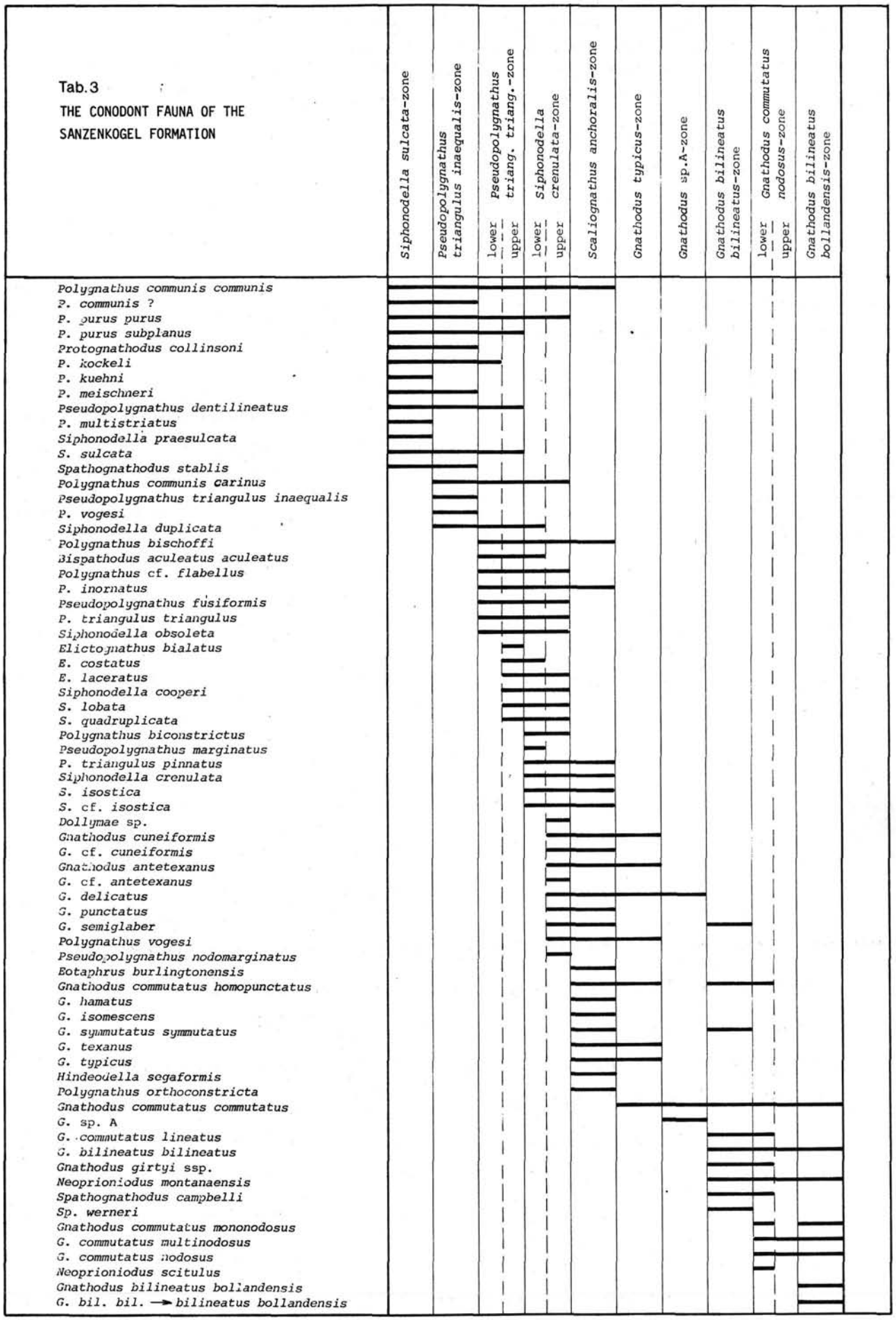
According to L. NÖSSING 1974 b, 1975 and F. EBNER 1978 both members show the following thicknesses of Lower Carboniferous conodont zones at the type localities:

Tab. 2
THE CONODONT FAUNA OF THE
STEINBERG LIMESTONE FORMATION



Tab. 3

THE CONODONT FAUNA OF THE SANZENKOGEL FORMATION

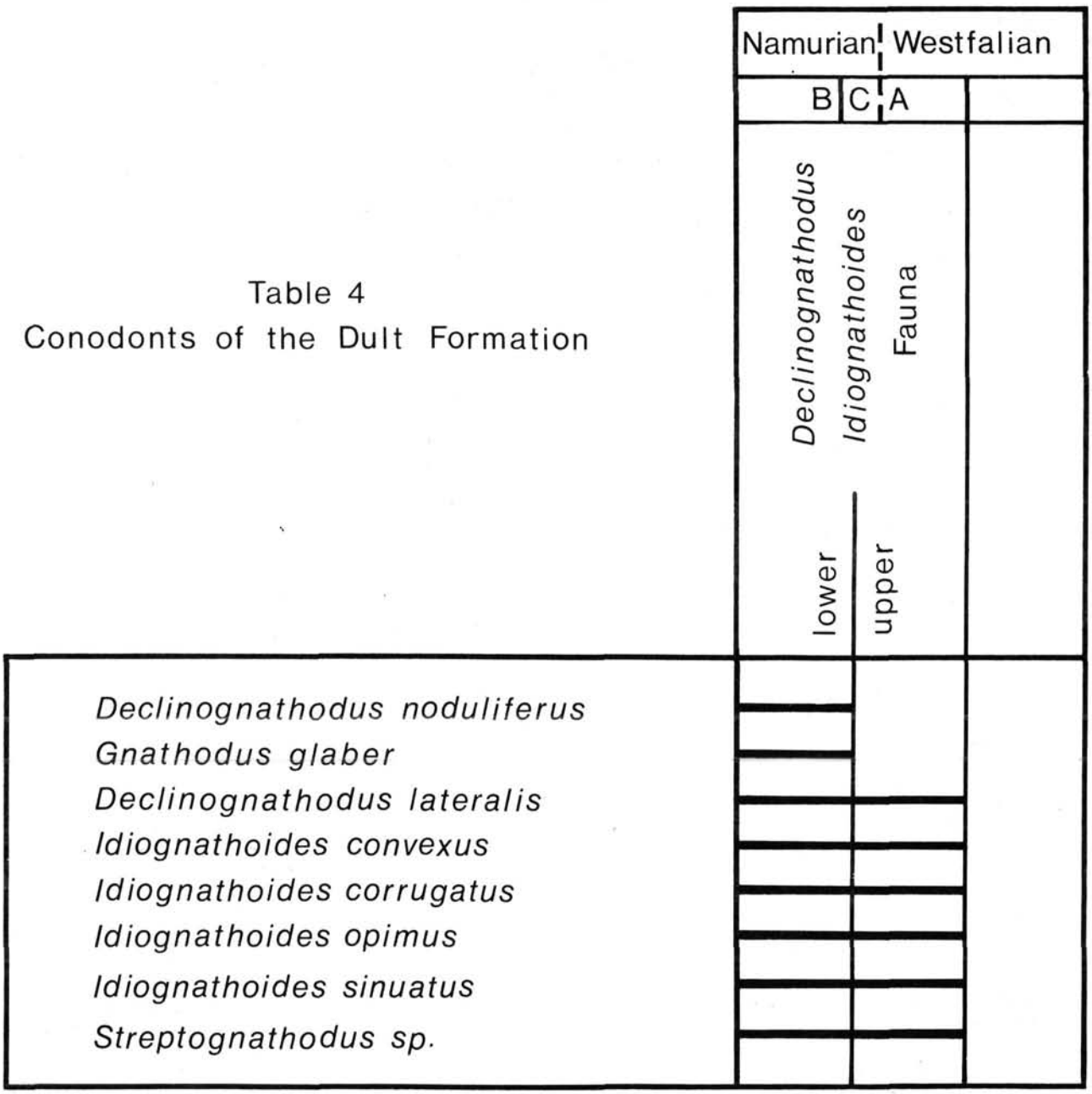


Siphonodella sulcata-Zone	35 cm
Pseudopolygnathus tr. inaequalis-Zone	30 cm
Pseudopolygnathus tr. triangulus-Zone	115 cm
Siphonodella crenulata-Zone	105 cm
Scaliognathus anchoralis-Zone	130 cm
Gnathodus typicus-Zone	215 cm
Gnathodus sp. A-Zone	400 cm
Gnathodus b. bilineatus-Zone	150 cm
Gnathodus comm. nodosus-Zone	960 cm
Gnathodus b. bollandensis-Zone	300 cm

Table 3 summarizes important conodonts of the Sanzenkogel Fm.

The pelagic Sanzenkogel Fm. is disconformably overlain by the shallow water deposits of the Dult Fm. ranging in age from Namurian B to early (?) Westfalian. Limestone lenses intercalated in shales produced rare conodont faunas (table 4). Locally stratigraphic admixtures occur at the base of the Dult Fm.

Table 4
Conodonts of the Dult Formation



2. The transition from Rannach facies to Hochlantsch facies

During the last couple of years progress has been made to date the so-called „Kalkschiefer Folge" by means of conodonts. This formation comprises normal marine platy limestones, marly limestones, nodular limestones etc. which are regarded as time-equivalents of the peritidal Dolomite-Sandstone Fm. According to M. F. BUCHROITHNER 1978, F. EBNER et al. 1979 and H. P. SCHÖNLAUB 1979 the following taxa of late Lochkovian, Pragian and Zlichovian ages have been found:

Belodella devonica (STAUFFER)
Belodella resima (PHILIP)
Icriodus latericrescens robustus ORR
Icriodus s. simulator CARLS
Pedavis pesavis (BISCHOFF & SANNEMANN)
Icriodus ? postwochmidti MASHKOVA
Neopanderodus sp.
Ozarkodina exc. wurmi (BISCHOFF & SANNEMANN)
Ozarkodina carinthiaca (SCHULZE)
Ozarkodina r. remscheidensis (ZIEGLER)
Pandorinellina st. steinhornensis (ZIEGLER)
Pandorinellina st. telleri (SCHULZE)
Pandorinellina st. miae (BULTYNCK)
Polygnathus cf. *gronbergi* KLAPPER & JOHNSON
Polygnathus l. linguiformis HINDE (gamma-morphotype)

Lithologically, Middle Devonian rocks of the transitional facies are closely related to the Rannach facies realm, e. g., the Barrandei Lst. and dolomites with *Amphipora*. They are succeeded by Kanzel Lst. equivalents, as for example, the 80 m thick limestones on top of mountain „Platzl-Kogel" from wich a small and bad preserved conodont fauna of the *varcus*-Zone has been isolated recently (F. EBNER et al. (1979):

Icriodus sp.
Neopanderodus perlineatus LINDSTRÖM & ZIEGLER
Polygnathus ovatinodosus ZIEGLER & KLAPPER
Polygnathus pseudofoliatus WITTEKINDT
Polygnathus timorensis KLAPPER, PHILIP & JACKSON
Polygnathus sp. ex gr. *linguiformis* HINDE
Polygnatus sp. ex gr. *xylus-varcus*

In other places, e. g., the Höllerer Kogel, styliolinid bearing Flaser limestones of Givetian age have been found. The corresponding conodont fauna includes:

Neopanderodus perlineatus LINDSTRÖM & ZIEGLER
Polygnathus l. linguiformis HINDE (gamma-morphotype)
Polygnathus sp. ex gr. *xylus-varcus*

Finally, Upper Devonian (Frasnian) conodonts occur at locality „Platzl-Kogel". F. EBNER et al. 1979 published the following taxa which are derived from a limestone-shale-sequence:

Ancyrodella buckeyensis STAUFFER
Ancyrodella sp.
Icriodus difficilis KLAPPER & ZIEGLER
Icriodus expansus BRANSON & MEHL
Icriodus nodosus (HUDDLE)
Palmatolepis del. delicatula BRANSON & MEHL
Palmatolepis quadrantinodosalobata SANNEMANN
Palmatolepis subrecta MILLER & YOUNGQUIST
Palmatolepis triangularis SANNEMANN
Polygnathus asymmetricus ssp. indet.
Polygnathus decorosus STAUFFER
Polygnathus ovatinodosus ZIEGLER & KLAPPER
Polygnathus xylus STAUFFER
Polygnathus sp. ex gr. *xylus-varcus*

So far the Middle/Upper Devonian boundary plane has not been recognized in the transitional facies.

3. Additional conodont localities in the vicinity of Graz

3.1 Laufnitzdorf:

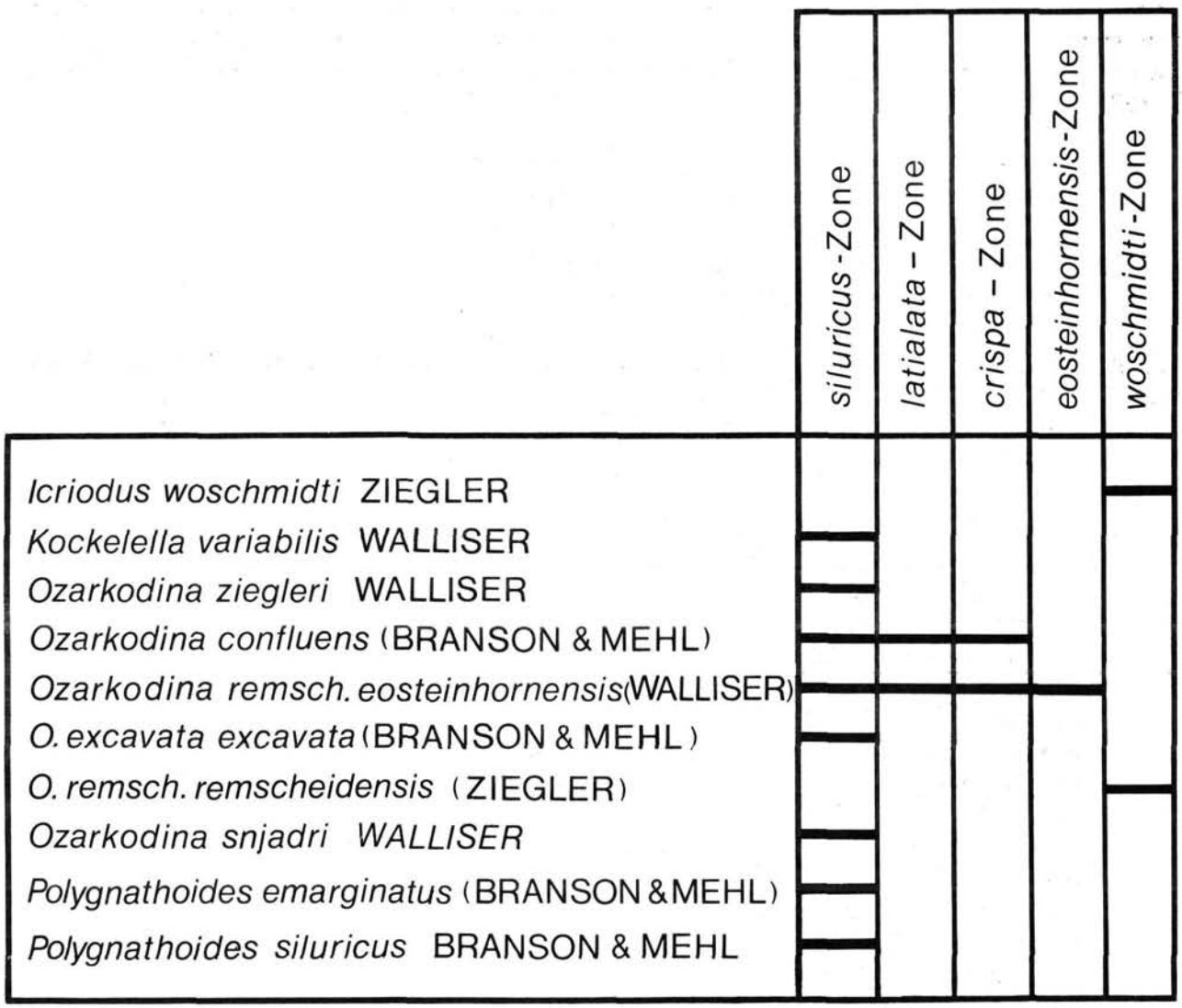
O. H. WALLISER in H. W. FLÜGEL 1961 and O. H. WALLISER 1964 identified a small Upper Silurian to Lower Devonian conodont fauna which has been found in dark bituminous limestones intercalated in shales. The conodont bearing exposures are part of a tectonically very complex zone and thus make it difficult for precise assignments to any of the facies mentioned above. The fauna includes the following form-taxa of Přidolian and Lochkovian age:

Ozarkodina ziegleri tenuiramea WALLISER
Ozarkodina ortuformis WALLISER
Icriodus sp.
Ozarkodina cf. *transitans* (BISCHOFF & SANNEMANN)
ramiform elements

3.2 Eggenfeld:

Close to the village Eggenfeld north of Graz F. EBNER 1976 described an interesting section with a fairly rich conodont fauna. A 15 m thick dolomite-limestone complex which overlies diabases produced diagnostic conodonts of the *siluricus*- to *woschmidti*-Zones (table 5).

In this section the conodonts are associated with other fossils, e. g., corals, crinoids, nautilids and brachiopods (*Septatrypa subsecrata* PLODOWSKI 1976).



Tab. 5: Diagnostic conodonts from the dolomite-limestone horizon at the Eggenfeld section (after F. EBNER 1976).

Guide to Devonian and Carboniferous Conodont Localities

STOP 1. Section Weihermühle

STOP 2. Section Hartbauer

STOP 3. Trolp Quarry

STOP 4. Forstkogel („Open air-theatre" Quarry)

STOP 5. Hahngraben

STOP 6. Section NNE of Dult Monastery

During ECOS II-Field Trip C in the Graz Paleozoic those sections will be visited which belong to the Rannach facies. The excursion provides the opportunity to see the stratigraphic record from the *Ancyrognathus triangularis*-Zone to the *Gnathodus bilineatus bollandensis*-Zone and even higher including strata dated as old as Namurian B.

As mentioned elsewhere in this guidebook the Middle/Upper Devonian boundary has not been traced with such an accuracy which is needed for precise correlation. This is mainly due to a rapid facies change from shallow water carbonates to cephalopod limestones in the presumed boundary interval making it extremely difficult to find sections with diagnostic conodonts in either facies.

The cephalopod limestone facies, lasting at certain places from the early Upper Devonian to the *Gnathodus b. bollandensis*-Zone (Namurian A) is subdivided into the Upper Devonian Steinberg Lst. and the Carboniferous Sanzenkogel Fm. Locally, these two formations are separated by a distinct unconformity caused by local rises of the Devonian carbonate basin during an early stage of the Variscan orogenesis. This stratigraphic gap increases from west towards east with a maximum gap from *marginifera*-Zone to the *Gnathodus b. bilineatus*-Zone. Frequently, at the base of the Upper Sanzenkogel Fm. stratigraphic admixtures can be found which correlate with the time of non-deposition. The reworked fauna consists of those elements which also have been found in the limestones below the unconformity plus those corresponding to the base of the overlying sequence. Interestingly, the missing column is never represented by any reworked conodonts.

Similar mixed conodont faunas can also be found as stratigraphic leaks. For example, at section Hartbauer stratigraphic leaks cut through the Steinberg Lst. almost from top to the base.

The continuous section across the Devonian/Carboniferous bundary are located west of the river Mur. They are characterized by

a) varying thicknesses of Upper Devonian conodont zones and

b) by extremely reduced thicknesses of Tournaisian sediments. In these sections the base of the Upper Sanzenkogel Fm. is marked by a thin shale-chert-phosphorite layer.

A second disconformity separates the Upper Sanzenkogel Fm. and the Dult Fm. In the section north of the Dult Monastery the Upper Sanzenkogel Fm. has been completely eroded. Hence, limestones of the Dult Fm. (Namurian B) conformably overlie the Steinberg Lst. The basal limestones of the Dult Fm. (= Dult Lst.) frequently contain mixed conodont faunas with elements referable to the corresponding erosional surface.

Study of microfacies suggests a shallow water environment for the Dult Lst. in which conodonts can hardly be found. This interpretation is supported by birdseye structures, occurrences of interstratal breccias and desiccation cracks. Laterally, the Dult Lst. passes into dark shales of the Dult Fm.; this horizon is associated in the shale sequence by hematite crusts.

In the Rannach facies realm sedimentation ended in the uppermost Namurian or early Westfalian stages.

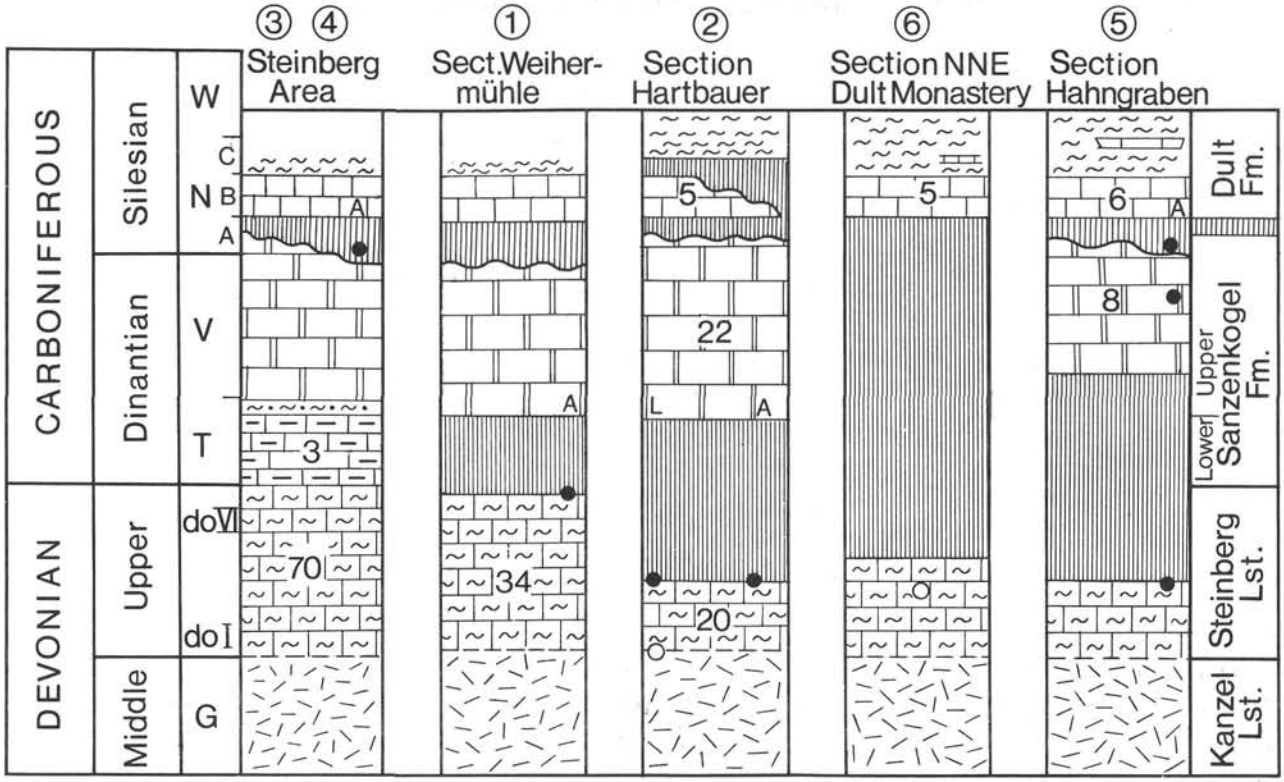


Fig. 3: Stratigraphy of conodont sequences visited during the excursion.
A Timing of stratigraphic admixtures
L Timing of stratigraphic leaks
● Reworked conodonts in mixed conodont faunas
o Position of stratigraphic leaks
Numbers: Thickness (meter)

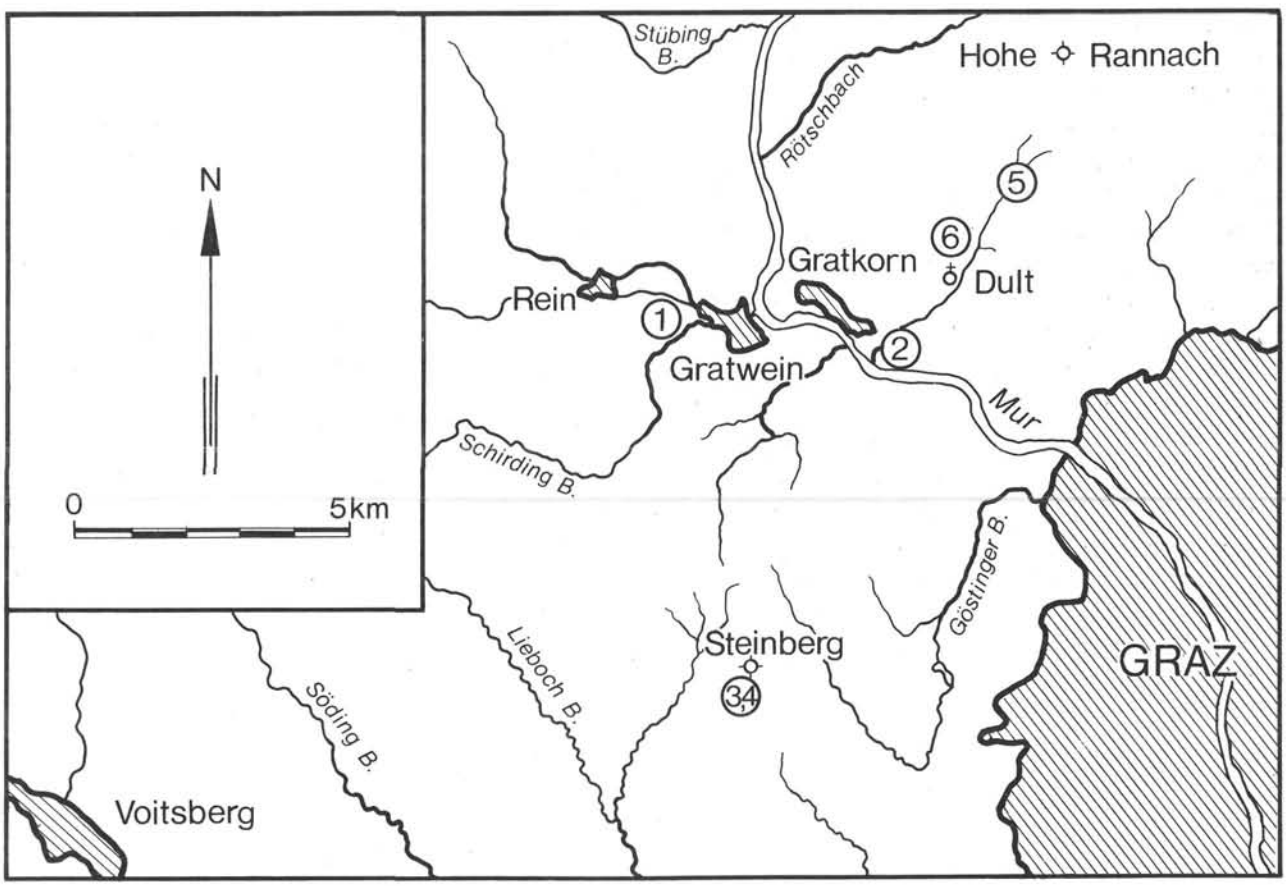


Fig. 4: Field trip stops in the Graz Paleozoic.

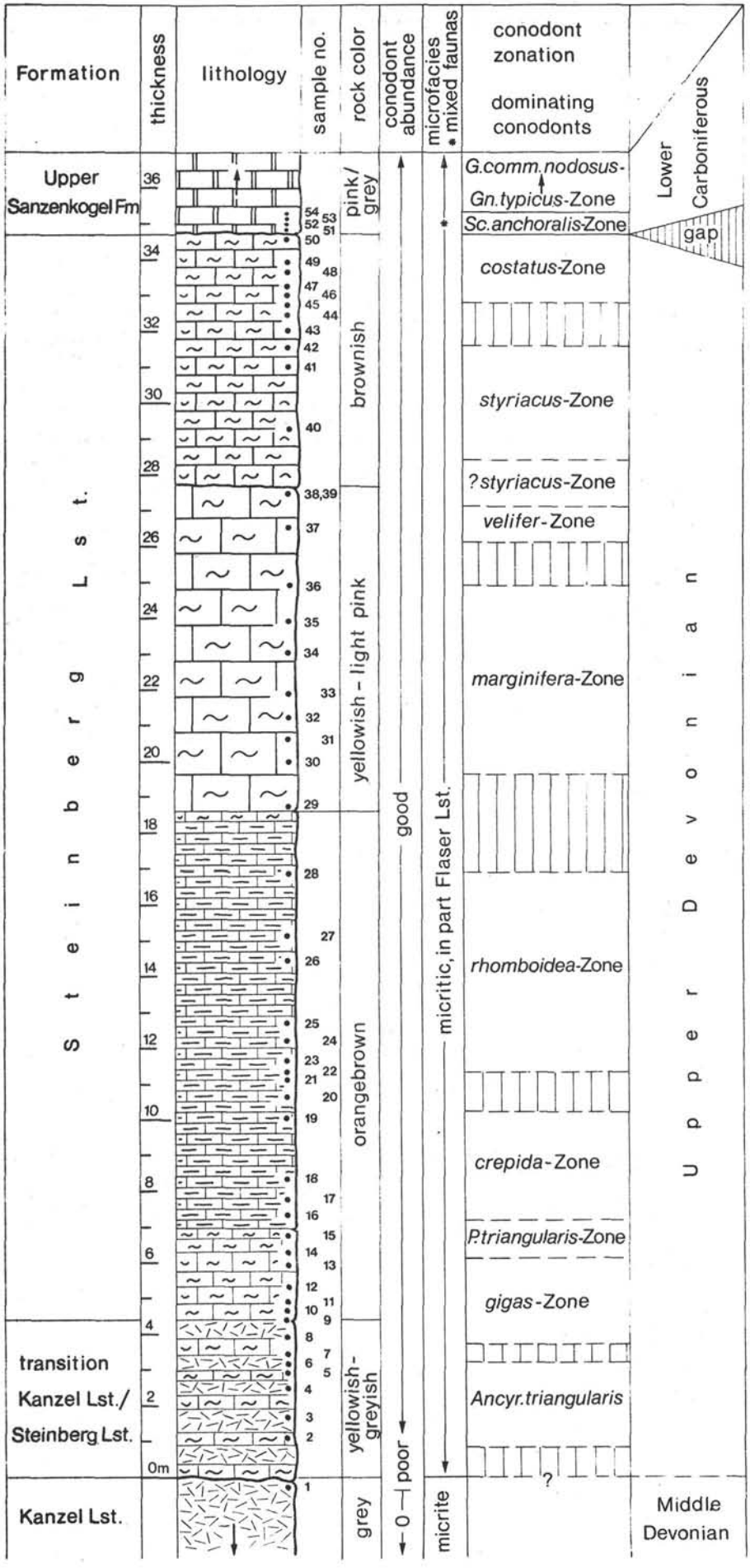
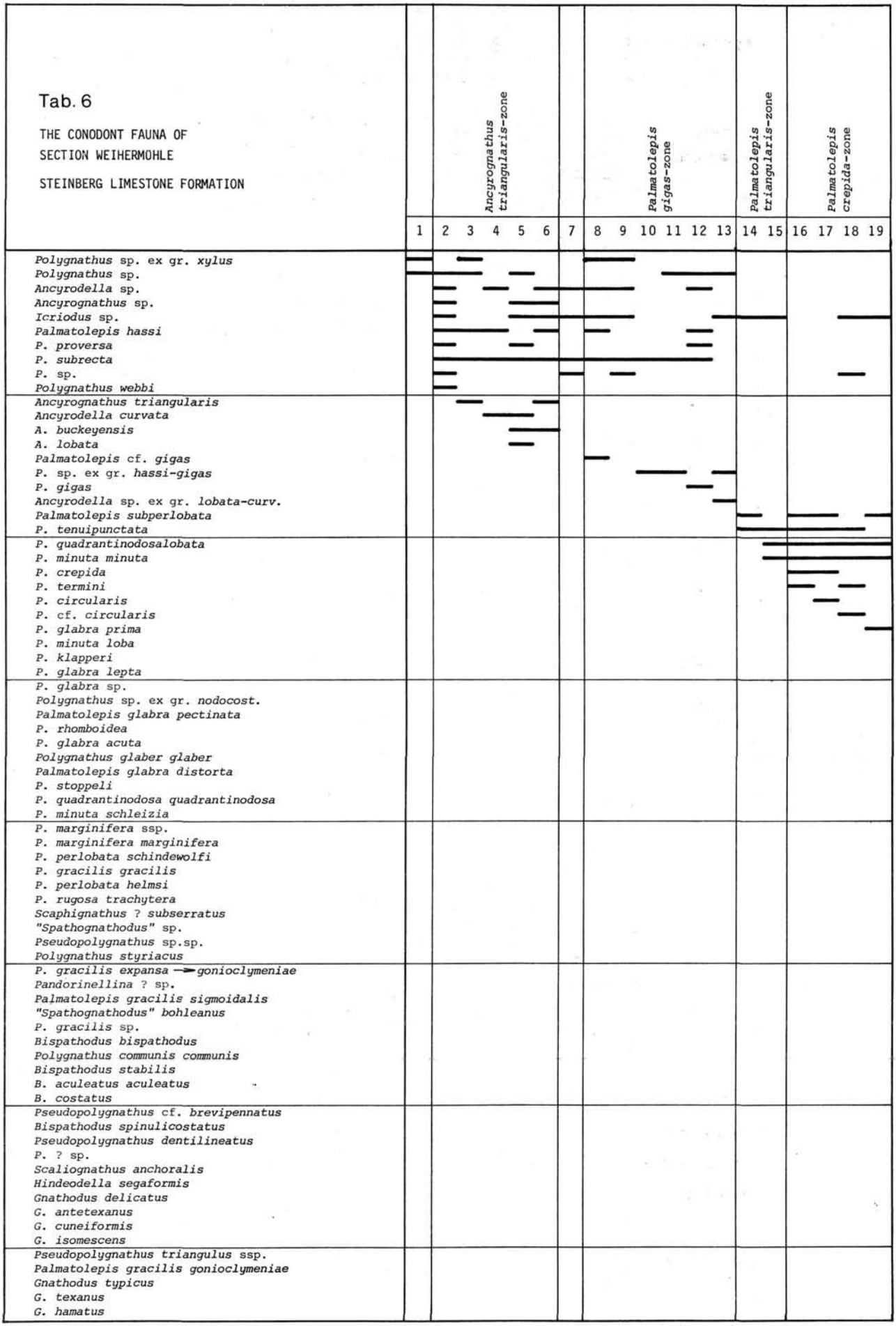


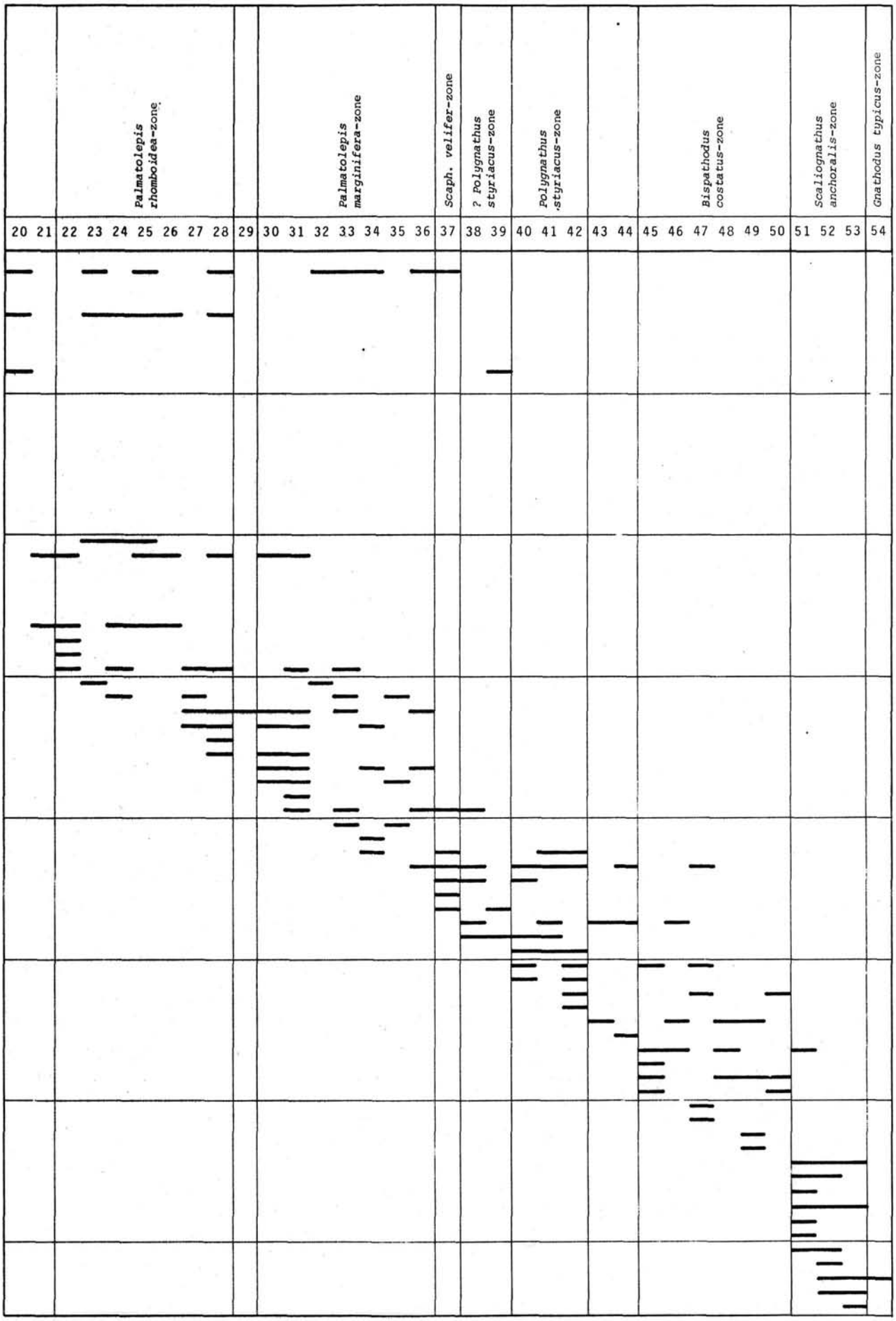
Fig. 5: Steinberg Lst. at section „Weihermühle".

Tab. 6

THE CONODONT FAUNA OF
SECTION WEIHERMÖHLE

STEINBERG LIMESTONE FORMATION




Palmatolepis rhomboidea-zone
Palmatolepis marginifera-zone
Scaph. velifer-zone
? Polygnathus styriacus-zone
Polygnathus styriacus-zone
Bispathodus costatus-zone
Scaliognathus anchoralis-zone
Gnathodus typicus-zone
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54

STOP 1. SECTION WEIHERMÜHLE

Kanzel Lst. – Steinberg Lst. (*Ancyrognathus triangularis*-Zone – *costatus*-Zone) – stratigraphic gap – upper Sanzenkogel Fm. (*Scaliognathus anchoralis*-Zone – *Gnathodus c. nodosus*-Zone).

In this section the Middle/Upper Devonian boundary has not been traced by conodonts yet. This is mainly due to a significant facies change occuring at this passage.

Biostratigraphically, section Weihermühle starts in the *A. triangularis*-Zone. In the succeeding pelagic Steinberg Lst. several Upper Devonian conodont zones have been recognized. They show the following thicknesses:

Conodont Zone	minimum thicknesses (cm)	maximum thicknesses (cm)
Gnathodus typicus– *Scaliogn. anchoralis*-Zone	400 70	
costatus-Zone	220	(+ 70)
styriacus-Zone	300	(+ 70)
? *styriacus*-Zone	130	
velifer-Zone	140	(+ 140)
marginifera-Zone	520	(+ 340)
rhomboidea-Zone	620	(+ 290)
crepida-Zone	350	(+ 90)
triangularis-Zone	100	
gigas-Zone	240	(+ 70)
A. triangularis-Zone	320	(+ 70)

The Steinberg Lst. are conformably overlain by the lithologically very similar Upper Sanzenkogel Fm. which have been dated – at this locality – as old as the *Scaliognathus anchoralis*-Zone. Hence, both formations are separated by a disconformity.

At the base of the Sanzenkogel Fm. reworked conodont faunas have been found. The section within the Sanzenkogel Fm. is badly exposed. In the uppermost beds conodonts of the *Gn. c. nodosus*-Zone have been identified.

Field notes: Red numbers are sample numbers as indicated in fig. 5.
Recommended samples: *Ancyrognathus triangularis – costatus*-Zone.

STOP 2. SECTION HARTBAUER

Kanzel Lst. – Steinberg Lst. (dol – *marginifera*-Zone) – gap – Upper Sanzenkogel Fm. (*Sc. anchoralis*-Zone – *Gn. b. bollandensis*-Zone) – Dult Fm. with Dult Lst. (with *Declinognathodus-Idiognathoides* fauna), and Dult Shale (Namurian C – ? Westfalian).

In this section too, at the base of the Steinberg Lst. a distinct facies break occurs. So far, the Steinberg Lst. section which may reach a thickness of some 20 m has not been studied in great detail. It's uppermost beds contain conodonts of the *P. marginifera*-Zone. They are conformably overlain by the Upper Sanzenkogel Fm. which has been dated as *Sc. anchoralis*-Zone at the base. Also, reworked faunas (stratigraphic admixtures) have been found in a 2 cm thick horizon at the base of the Upper Sanzenkogel Fm. This mixed fauna contains conodonts of the *P. marginifera*-Zone and the overlying strata of Tournaisian age. Stratigraphic leaks have been found too occuring from the unconformity through the Steinberg Lst. almost to the boundary between Kanzel Lst. and Steinberg Lst. Recognition of these phenomena, however, is extremely difficult.

The Upper Sanzenkogel Fm. reaches a thickness of approx. 22 m. Near the base lydites have been found. The uppermost part have yielded conodonts belonging to the *Gn. b. bollandensis*-Zone. Unconformably, they are followed by the Dult Fm. with 5 m thick Dult Lst. at the base. These limestones, in turn, are separated from the shales above by a disconformity which is marked by hematite crusts.

In the Upper Sanzenkogel Fm. conodont frequency varies considerably. In particular, this is true for the interval between the *Gn. typicus* and *Gn. b. bilineatus*-Zones during which conodont abundance is very poor. Those conodonts which have been found are very small and also, very thin; they are described as *Gnathodus* sp. A.

Gnathodus sp. A: Small asymmetrical cup (platform) with an acute posterior end. In oral view the platform may be smooth or ornamented by few nodes. The inner part of the platform bears a short and low parapet.

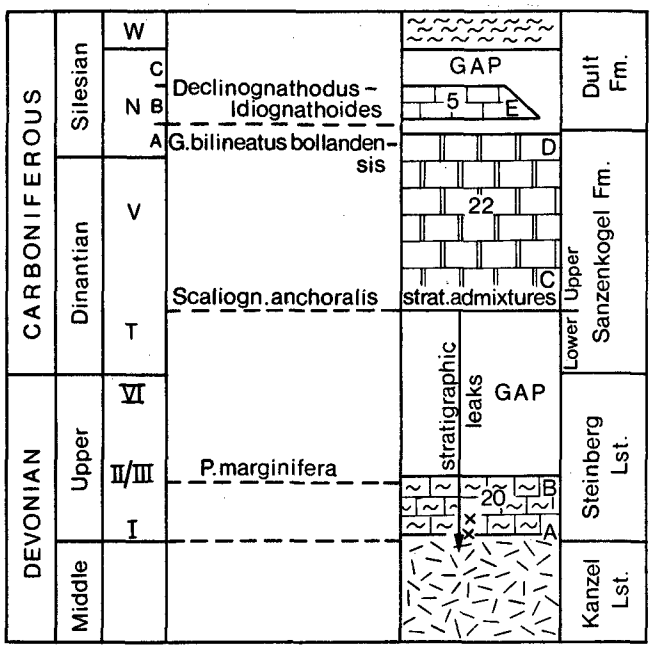


Fig.6: Stratigraphy of section „Hartbauer".
A–E: red field marks.

During the range of *Gn. c. nodosus* a second interval with decreased conodont abundance has been recognized in a horizon of 6 m thickness above equivalents to cu IIIß/gamma strata which are characterized by the occurrences of *Gn. commutatus* and *Sp. campbelli* (Lower *Gn. c. nodosus*-Zone).

The Visean/Namurian boundary should be placed above this level. The highest parts of the Sanzenkogel Fm. are characterized by distinct changes of the conodont faunas on a subspecies level, i. e., from *Gn. b. bilineatus* to *Gn. b. bollandensis* (more slender platforms and an almost smooth outer part of the platform). Interestingly, within the range of *Gn. b. bollandensis,* a second occurrence of *Gn. c. mononodosus* has been observed.

In the following Dult Lst. two specimens belonging to *Idiognathoides opimus* have been found.

Red marks:
A: Boundary horizon Kanzel Lst./Steinberg Lst.
B: Top of Steinberg Lst.
C: Base of Upper Sanzenkogel Fm.
D: Top of Upper Sanzenkogel Fm.
E: Base of Dult Lst.
X: Mixed conodont faunas.

Red numbers indicate samples within the Upper Sanzenkogel Fm. drawn in fig. 7.

Recommended samples: Upper Sanzenkogel Fm. in the limestone between the lydite and the Dult Lst. (*Gnathodus* sp. A-Zone – *Gn. b. bilineatus*-Zone).

References: F. EBNER 1976 a, 1977 a, 1977 b, 1978.

STOP 3. TROLP QUARRY

Steinberg Lst. (*P. styriacus*-Zone, *B. costatus*-Zone, *Protognathodus*-Fauna); Sanzenkogel Fm. (*Siph. sulcata*-Zone – *Gn. typicus*-Zone).

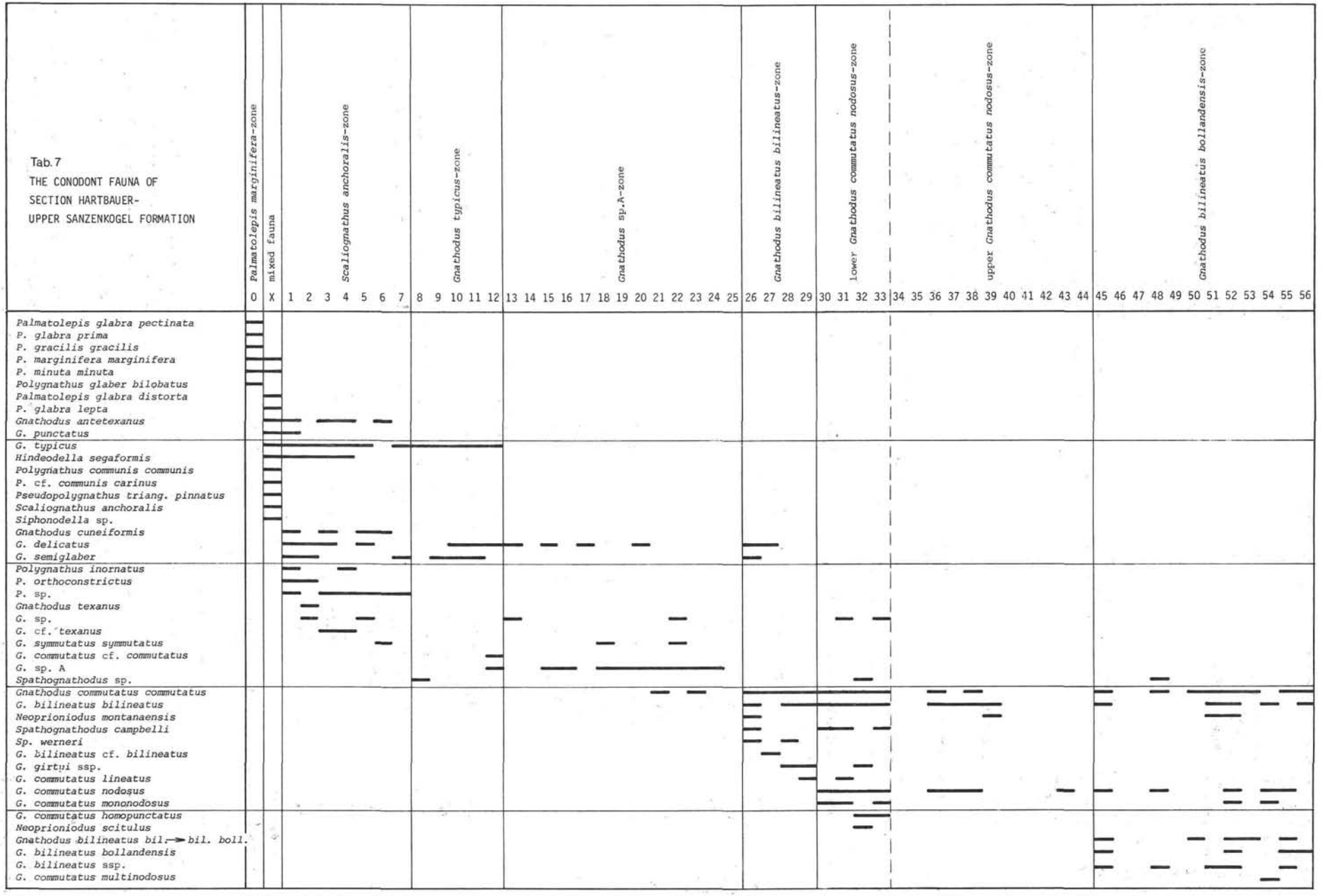
Trolp quarry is the type locality of *Polygnathus styriacus* first described by W. ZIEGLER 1957. According to H. W. FLÜGEL & W. ZIEGLER 1957 in the northern wall of the abondoned quarry the following conodonts have been identified:

Palmatolepis gracilis gracilis MÜLLER
Palmatolepis perlobata ULRICH & BASSLER
Polygnathus styriacus ZIEGLER
Polygnathus communis BRANSON & MEHL
Pseudopolygnathus micropunctatus BISCHOFF & ZIEGLER
Spathognathodus stabilis (BRANSON & MEHL)
Spathognathodus tridentatus (BRANSON)

The type section of the Lower Sanzenkogel Fm. is located in the east face of the quarry. The upside down section which is represented by coarse bedded micritic Flaser-limestones begins in the *B. costatus*-Zone and ends in the *Gn. typicus*-Zone. At the base of the *Scaliognathus anchoralis*-Zone a 20 cm thick shale-chert-phosphorite-intercalation occurs within the more or less uniform developed limestone sequence.

The type section was first established by L. NÖSSING 1974 a, b, 1975. Due to the fact, that his original sample numbers have been destroyed and lost, a restudy has been started which concentrates on conodonts of the passage from the Devonian to the Carboniferous, and also, across the Tournaisian/Vi-

Tab. 7
THE CONODONT FAUNA OF
SECTION HARTBAUER-
UPPER SANZENKOGEL FORMATION



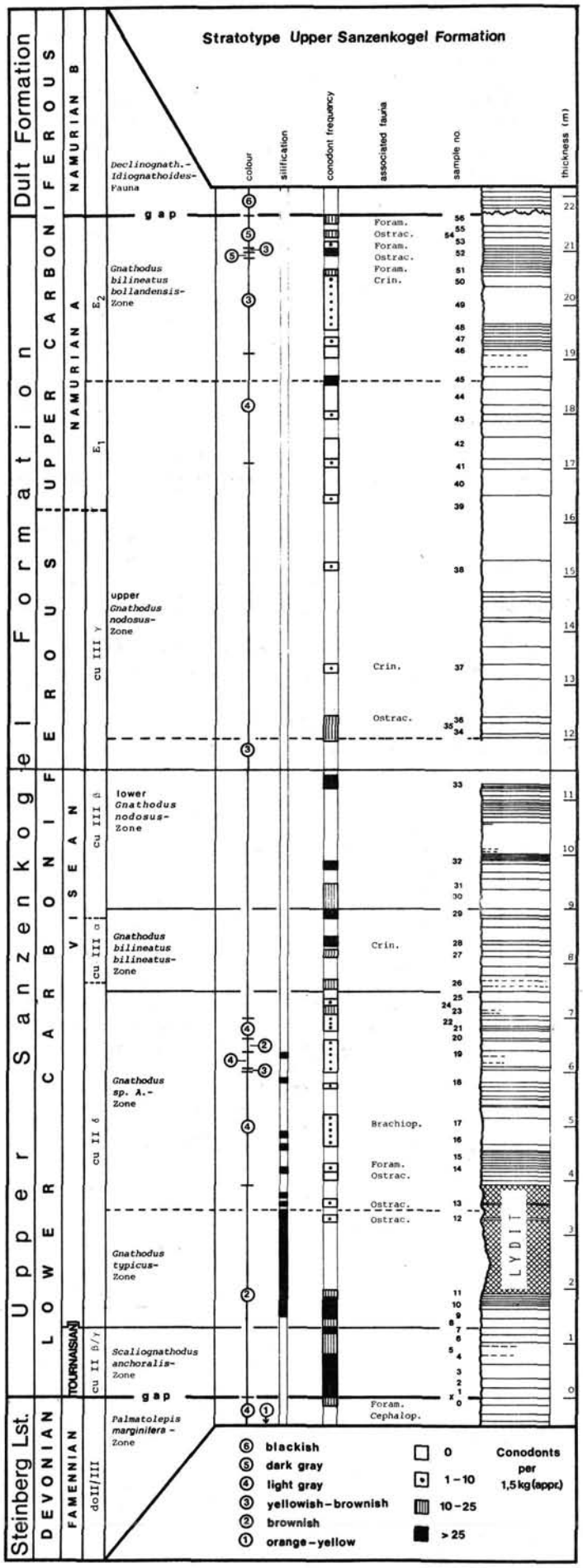


Fig. 7: Stratotype of the Upper Sanzenkogel Fm. at section „Hartbauer".

sean boundary. Another goal has been to check whether Dinantian conodont zonation based on the genus *Siphonodella* (Ch. A. SANDBERG et al. 1978, 1979) can be used to subdivide rocks of this age. Finally, a campaign to collect cephalopods is planned for the future. Thus, data shown in fig. 8, tab. 8 are only preliminary to demonstrate our present knowledge of this important section.

Distribution of the genus *Siphonodella* is restricted to certain beds. This fact makes it difficult for use of the zonation based on siphonodellids, in particular, across the Devonian/Carboniferous transitional beds and within the interval from the *Siph. sulcata*-Zone to the *Ps. tr. inaequalis*-Zone (*Siph. duplicata* to *Siph. sandbergi*-Zone).

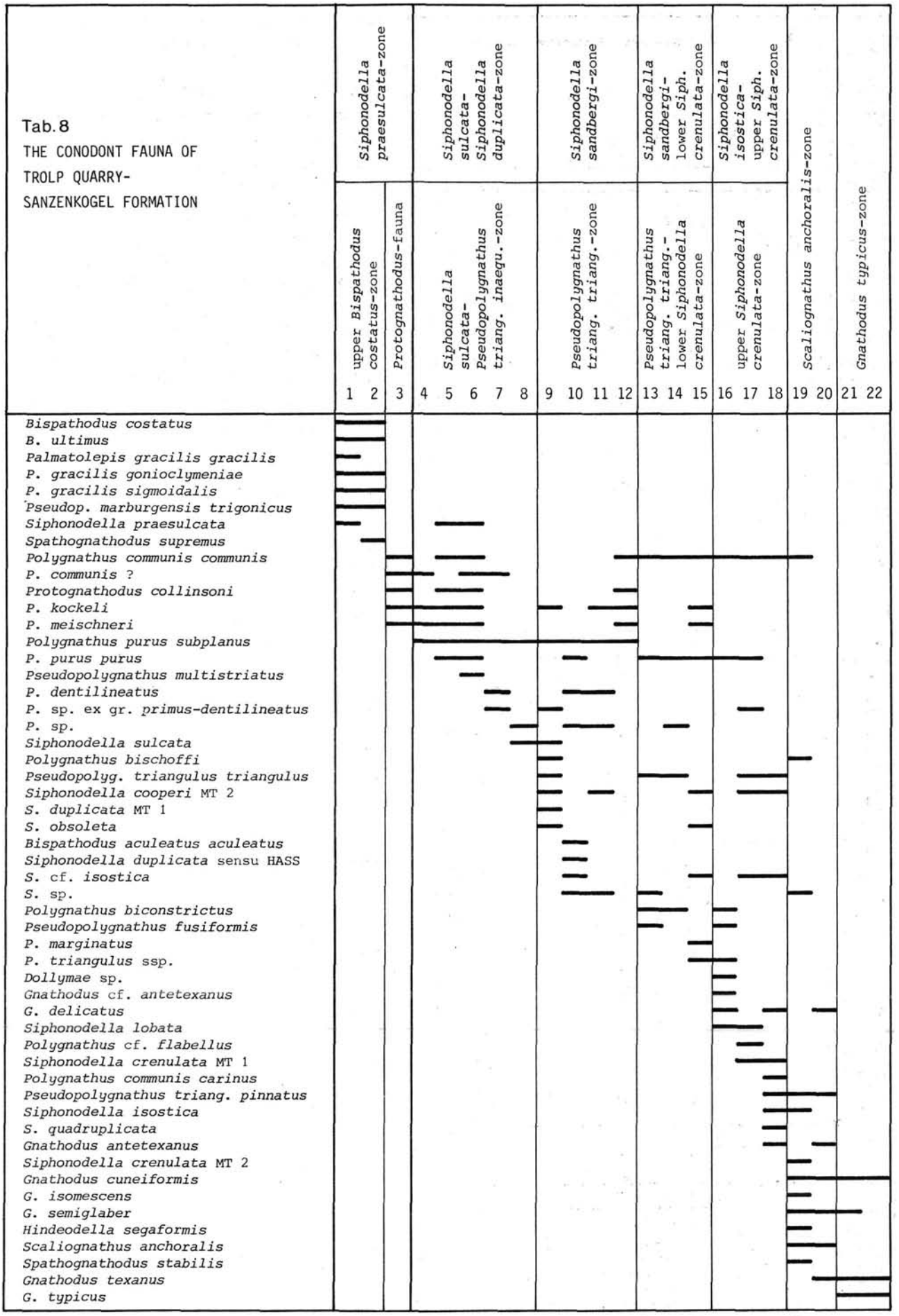
Due to rare occurrences of *Siph. sulcata* in this section the Devonian/Carboniferous boundary is drawn above a 15–20 cm thick horizon which is dominated by representatives of the genus *Protognathodus* and below the appearance of *Pol. purus subplanus* and *Pol. p. purus*. Interestingly, in this section the genus *Siphonodella* has also been found in the lower *Sc. anchoralis*-Zone.

F i e l d n o t e s : Red numbers are sample numbers corresponding to fig. 8.

R e c o m m e n d e d s a m p l e s : Upper *B. costatus*-Zone; *Protognathodus*-Fauna – Upper *Siph. crenulata*-Zone; *Sc. anchoralis*-Zone; *Gn. typicus*-Zone.

R e f e r e n c e s : H. W. FLÜGEL & W. ZIEGLER 1957, L. NÖSSING 1974 a, b, 1975.

Tab. 8
THE CONODONT FAUNA OF
TROLP QUARRY-
SANZENKOGEL FORMATION



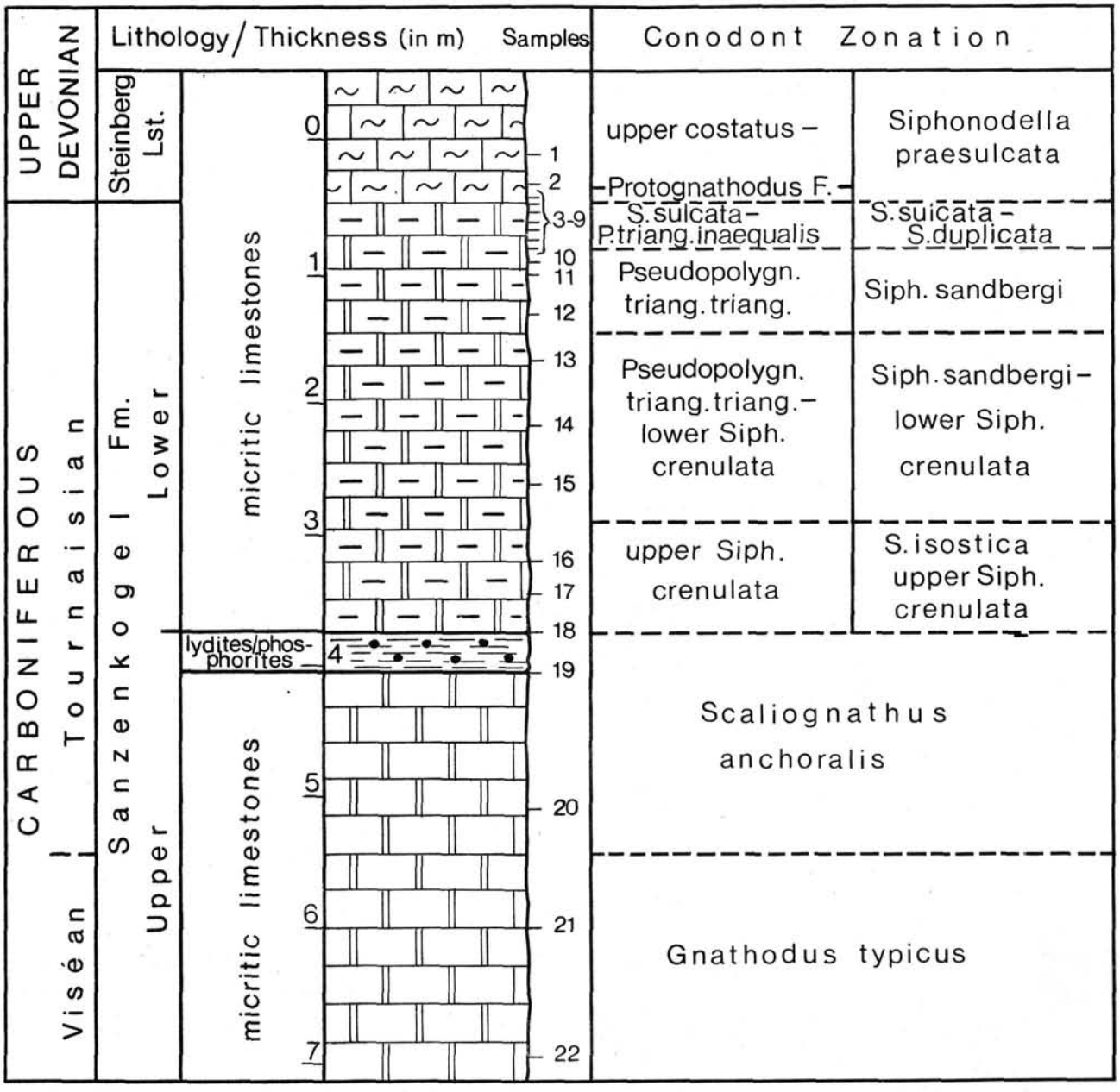


Fig. 8: Stratotype of the Lower Sanzenkogel Fm. at Trolp Quarry.

STOP 4. FORSTKOGEL („Open air-theatre" Quarry)

Steinberg Lst. and Sanzenkogel Fm. (Upper Devonian, Lower Carboniferous).

The Forstkogel is the classical locality for the Steinberg Lst. development. In this area, however, there is some lack of good exposures but even worse is the complex tectonic which affected all rocks. Actually, it is impossible to demonstrate in one single section a continuous sequence of Upper Devonian strata.

According to R. SURENIAN 1977 thicknesses of certain conodont zones vary considerably within short distances; locally, due to strong currents, some conodont zones are even missing (M. F. BUCHROITHNER et al. 1979).

During the last century in the Forstkogel area the colored cephalopod bearing Steinberg Lst. was abundantly quarried. The rocks became famous all around Graz for use as building material. Today the quarries are mostly used for recreation purposes or sporting sites of a nearby nursery school.

The tectonically complex structure of the Steinberg Lst. and the Sanzenkogel Fm. at this stop is demonstrated in fig. 9 (R. SURENIAN 1977). In this figure the tectonic of the quarry „Open air-theatre" (Freilichtbühne) is also shown. In some cases isoclinal folding was so strong to produce normal and upside down sequences of lithologically similar Steinberg Lst. and Sanzenkogel Fms.

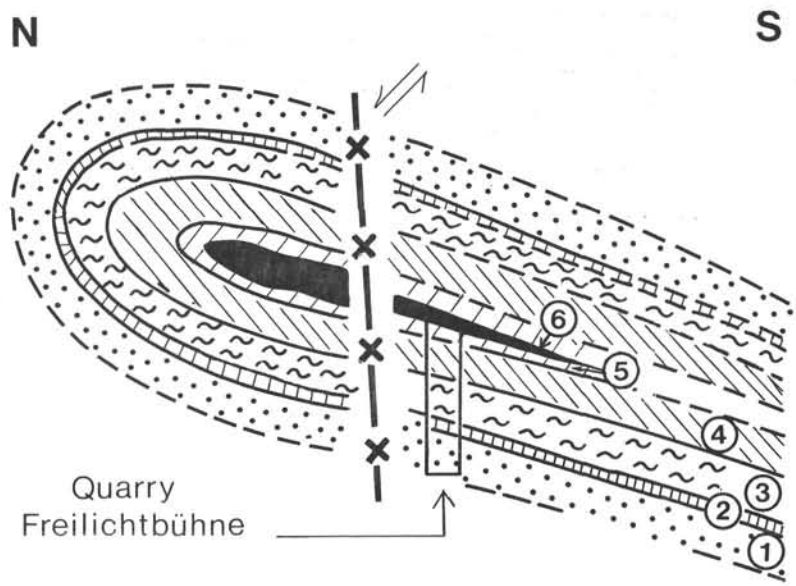


Fig. 9: Tectonic sketch of the area around Forstkogel; square indicates the open-air theatre quarry (according to R. SURENIAN 1977).

1–4: Steinberg Lst.
1: *P. marginifera*-Zone
2: *P. velifer*-Zone
3: *Pol. styriacus*-Zone
4: *B. costatus*-Zone
5–6: Sanzenkogel Fm.
5: cu I
6: cu II

(A) In the northern wall of the quarry the *P. marginifera*-Zone has been proved reaching a thickness of more than 6.00 m; also, the *B. costatus*-Zone with a thickness of 3.00 m has been found. Yet, *velifer*-Zone, *styriacus*-Zone and the *Protognathodus*-Fauna have not been recognized. The normal sequence of this section ranges into the *Gn. typicus*-Zone. This horizon is tectonically overlain (overfolded) by an upside down sequence of the Sanzenkogel Fm. plus Steinberg Lst. as illustrated in fig. 9.

Within the *Sc. anchoralis*-Zone a thin phosphorite bearing shale horizon has been found in the normal sequence.

(B) In the southeastern part of the quarry the *Pol. styriacus*-Zone is represented by limestones of more than 4.50 m thickness; in addition, the *B. costatus*-Zone has been proved in limestones of more than 7,50 m thickness.

(C) In the north-western corner of the quarry the following zones have been recognized in normal order:

marginifera-Zone: more than 3.00 m thick

velifer-Zone:	3.70 m thick
styriacus-Zone:	more than 3.70 m thick
costatus-Zone:	more than 2.50 m thick.

(D) In the gorge which leads to the quarry limestones of the *Pol. styriacus*-Zone have been found in the northern part; in the southern part of the gorge equivalents of the *B. costatus*-Zone occur.

Caused by karst, at this place the Flaser-limestones are deeply excavated and porous. They are re-filled by red soils of Plio- and Pleistocene ages. Conodonts have been discovered in these soils indicating the residual nature of the soil. According to R. SURENIAN 1977, for example, from 3 kg of soil a mixed conodont fauna composed of 71 single elements has been isolated. They span the time from basal Famennian to the *Gattendorfia* Stage. Preservation of the conodonts is relatively good.

F i e l d n o t e s : Red letters A to D indicate the location of the sections mentioned in the guidebook.

R e f e r e n c e s : R. SURENIAN 1977, 1978, M. F. BUCHROITHNER et al. 1979, H. W. FLÜGEL & W. ZIEGLER 1957, H. HÖLLER 1958.

STOP 5. HAHNGRABEN

Steinberg Lst. *(P. marginifera*-Zone) – stratigraphic gap – Upper Sanzenkogel Fm. *(Gn. b. bilineatus*-Zone to *Gn. c. nodosus*-Zone) – stratigraphic gap – Dult Lst.(*Declinognathodus-Idiognathoides*-Fauna).

The yellowish micritic Steinberg Lst. yielded conodonts of the *P. marginifera*-Zone. They are succeeded by the Upper Sanzenkogel Fm. which here begins in the *Gn. b. bilineatus*-Zone. Hence, both formations are separated by an unconformity assuming a stratigraphic gap. The Upper Sanzenkogel Fm. consists of light grey, in part clayey and bedded limestones of a thickness of 7.60 m. They are overlain by black Dult Lst. of 6.00 m thickness.

Dult Lst. and Upper Sanzenkogel Fm. are also separated by a disconformity. At the base of the overlying Dult Lst. reworked conodonts have been found. They represent diagnostic elements of the Steinberg Lst. and the Upper Sanzenkogel Fm.

Sedimentological criteria such as desiccation cracks and breccias are in good accordance with the conodont data which imply a distinct disconformity.

In samples from the base of the Upper Sanzenkogel Fm. Upper Devonian conodonts of the underlying Steinberg Lst. have been found, i. e., *Palmatolepis* sp. They occur as high as 1.80 m above the disconformity. The Dult Fm. too contains mixed conodont faunas and in situ faunas; the latter belong to the Namurian B (= lower *Declinognathodus-Idiognathoides*-Fauna). Furthermore, conodonts of Upper Devonian, Viséan, and Namurian A strata have been found which correspond with the lower limit of the disconformity.

F i e l d n o t e s : Red numbers: 1. Top of Steinberg Lst.; 2. Approx. upper limit of the *Gn. b. bilineatus*-Zone; 3. Top of Sanzenkogel Fm.; 4. Base of Dult Lst.

R e c o m m e n d e d s a m p l e s : Dult Lst. with an in situ fauna of Namurian B age. However, frequency of conodonts may vary to a certain degree. In general, yellowish-brownish rocks produced richer faunas (mixed conodonts) than black micritic limestones.

R e f e r e n c e s : F. EBNER 1976 a, 1977 a, b, 1978.

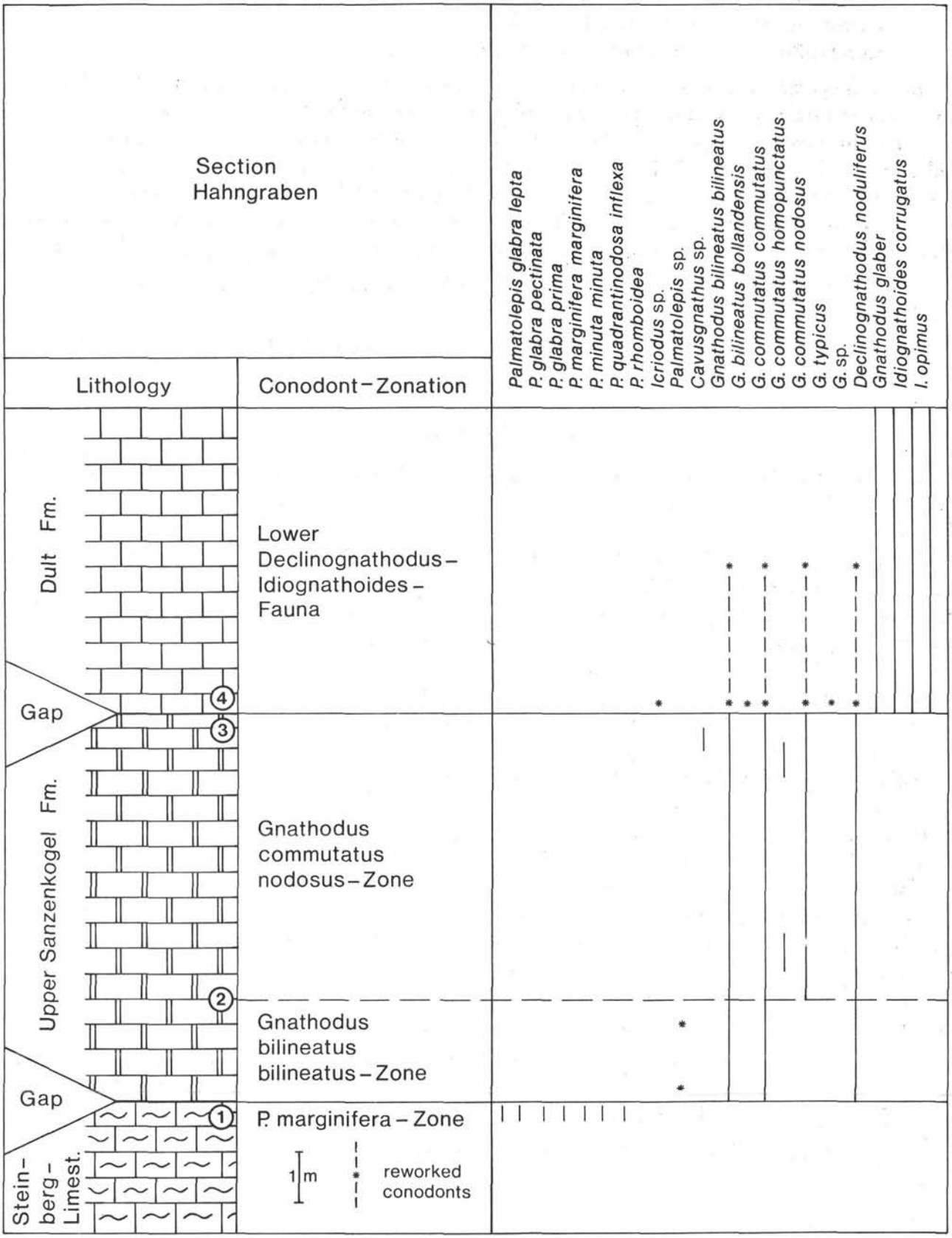


Fig. 10: Stratigraphy and conodonts of section „Hahngraben"

STOP 6. SECTION NNE OF DULT MONASTERY

Steinberg Lst. *(P. marginifera*-Zone to *P. velifer*-Zone) – stratigraphic gap – Dult Lst. (lower *Declinognathodus – Idiognathoides*-Fauna).

The yellowish and brownish micritic Steinberg Lst. with conodonts representing the *marginifera*- to *velifer*-Zone are overlain by coarse bedded dark Dult Lst. Both formations are separated by a distinct unconformity. Yet, this section is the only one known in which the Dult Lst. overlies the Steinberg Lst. Hence, we assume, that the Sanzenkogel Fm. has been eroded prior to deposition of the Dult Lst. This conclusion is supported by a nearby section with a thin horizon exhibiting the Sanzenkogel Fm. and, also, in section Hahngraben with mixed Upper Devonian and Lower Carboniferous conodont faunas found in the basal Dult Lst.

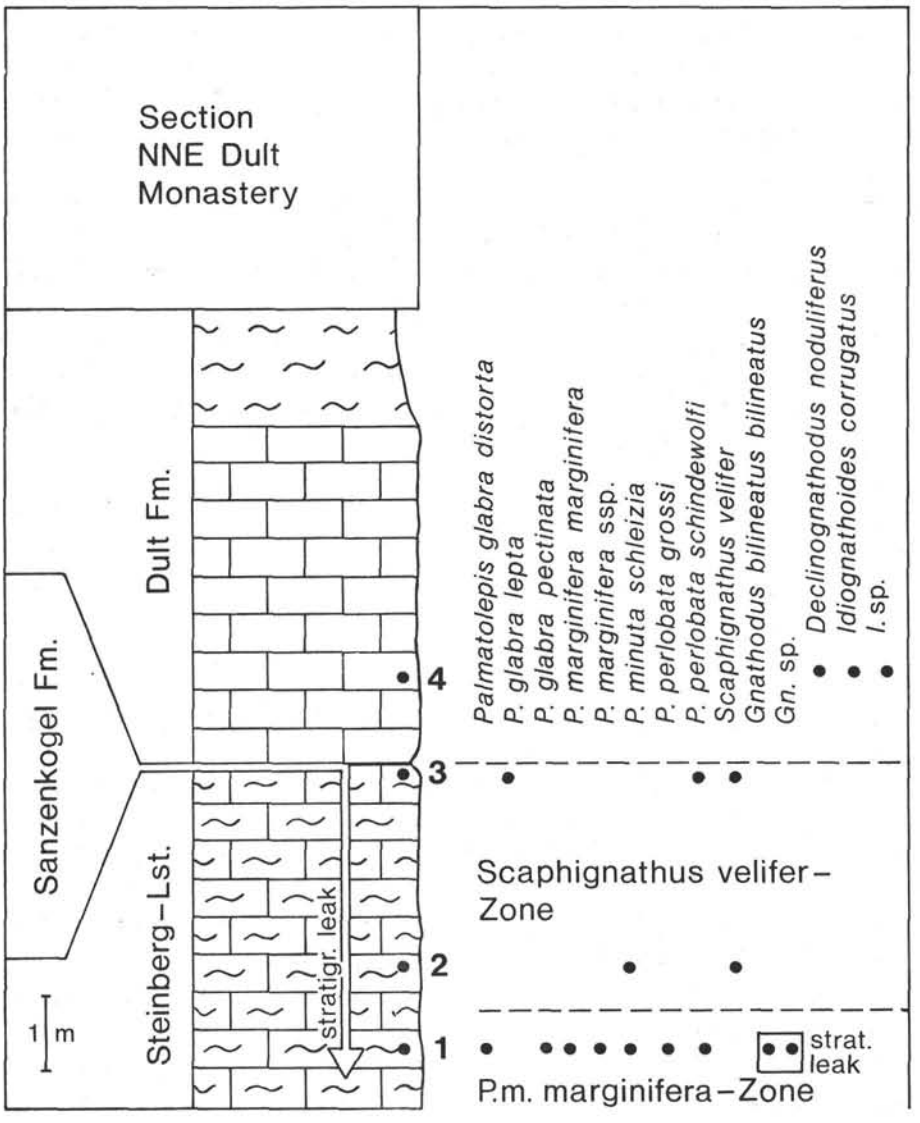


Fig. 11: Stratigraphy and conodont occurrences of section „NNE Dult Monastery". Numbers indicate red field marks.

Furthermore, we draw attention to the fact that in sample no. 1 mixed conodont faunas (stratigraphic leak) occur; they belong to the *P. marginifera*- and *Gn. b. bilineatus*-Zones! This is another proof for deposition of the Sanzenkogel Fm. on top of the Steinberg Lst. However, they have been completely eroded before sedimentation of the Dult Lst. began.

F i e l d n o t e s : Red numbers: 1. *P. marginifera*-Zone; 2, 3: *P. velifer*-Zone; 4: Namurian B (lower *Declinognathodus–Idiognathoides*-Fauna).

R e c o m m e n d e d s a m p l e s : Dult Lst., bed no. 4 with relatively abundant conodonts of the *Declinognathodus–Idiognathoides*-Fauna.

Horizon between bed no. 2 and 3 with conodonts of the *P. velifer*-Zone.

R e f e r e n c e s : F. EBNER 1976 a, 1977 a, b, 1978.

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Plate 15

Mag. 60 x

Carboniferous of Graz

Figs. 1–4: *Gnathodus* sp. A. EBNER 1977; Section Hartbauer, Upper Sanzenkogel Fm., *Gnathodus* sp. A-Zone.

Fig. 5: *Gnathodus bilineatus bilineatus* (ROUNDY 1926); Section Hartbauer, Upper Sanzenkogel Fm., *Gnathodus bilineatus bilineatus*-Zone.

Fig. 6: *Gnathodus commutatus mononodosus* RHODES, AUSTIN & DRUCE 1969; Section Hartbauer, *Gnathodus bilineatus bollandensis*-Zone.

Fig. 7: *Gnathodus commutatus commutatus* (BRANSON & MEHL 1941); Section Hartbauer, Upper Sanzenkogel Fm., Upper *Gnathodus commutatus nodosus*-Zone.

Figs. 8, 9: *Gnathodus commutatus nodosus* BISCHOFF 1957; Section Hartbauer, Upper Sanzenkogel Fm.
Fig. 8: *Gnathodus bilineatus bollandensis*-Zone, fig. 9: *Gnathodus commutatus nodosus*-Zone.

Fig. 10: *Gnathodus commutatus multinodosus* HIGGINS 1962; Section Hartbauer, Upper Sanzenkogel Fm., *Gnathodus bilineatus bollandensis*-Zone.

Figs. 11, 12: *Gnathodus bilineatus bollandensis* HIGGINS & BOUCKAERT 1968; Section Hartbauer, Upper Sanzenkogel Fm., *Gnathodus bilineatus bollandensis*-Zone.

Fig. 13: *Gnathodus bilineatus bilineatus* → *Gnathodus bilineatus bollandensis;* Section Hartbauer, Upper Sanzenkogel Fm., *Gnathodus bilineatus bollandensis*-Zone.

Figs. 14–18: *Declinognathodus noduliferus* (ELLISON & GRAVES 1941); Dult Fm., Lower *Declinognathodus-Idiognathoides*-Fauna.
Figs. 14, 15, 17, 18: Sanzenkogel, fig. 9: Höchkogel.

Figs. 19–21: *Declinognathodus lateralis* (HIGGINS & BOUCKAERT 1968); Sanzenkogel, Dult Fm., Lower *Declinognathodus-Idiognathoides*-Fauna.

Figs. 22–24: *Gnathodus glaber* WIRTH 1967; Gratwein/Au, Dult Fm., Lower *Declinognathodus-Idiognathoides*-Fauna.

Figs. 25–29: *Idiognathoides convexus* (ELLISON & GRAVES 1941); Section Hahngraben, Dult Fm., Lower *Declinognathodus-Idiognathoides*-Fauna.
Figs. 28, 29 transition forms to *Gnathodus glaber* WIRTH 1967.

Figs. 30–32: *Idiognathoides corrugatus* (HARRIS & HOLLINGSWORTH 1933); Dult Fm., Lower *Declinognathodus-Idiognathoides*-Fauna.
Fig. 30: Section NNE Dult Monastery, figs. 31, 32: Section Hahngraben.

Fig. 33: *Idiognathoides opimus* (IGO & KOIKE 1964); Section Hahngraben, Dult Fm., Lower *Declinognathodus-Idiognathoides*-Fauna.

Figs. 34–35: *Idiognathoides sinuatus* HARRIS & HOLLINGSWORTH 1933; NNE Dult Monastery, Dult Fm., Upper *Declinognathodus-Idiognathoides*-Fauna.

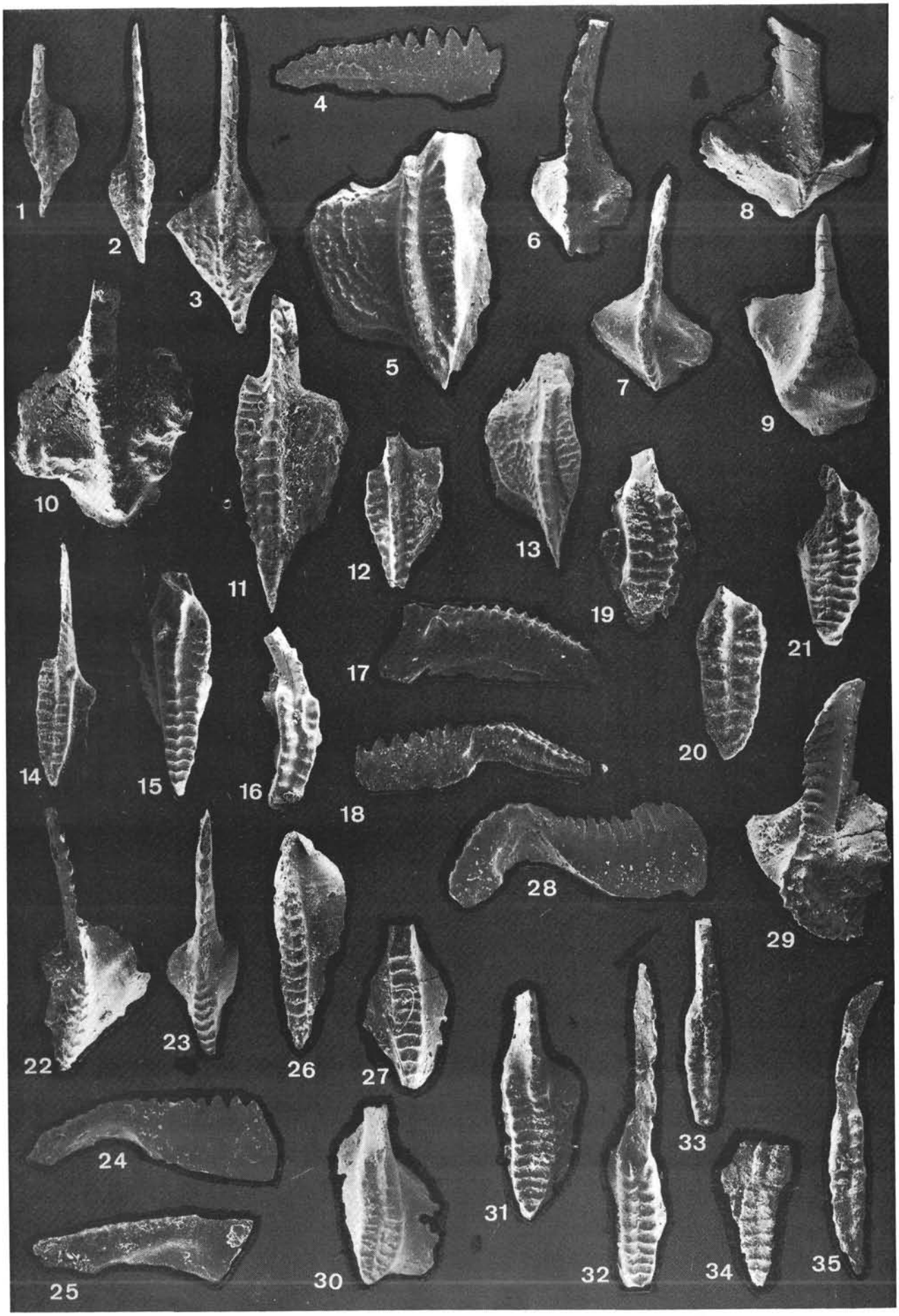
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Plate 16

Carboniferous (Upper Devonian) of Graz

Fig. 1: *Siphonodella praesulcata* SANDBERG 1972. Steinberg Lst., upper *costatus*-Zone, Trolp Quarry (0,66 mm).

Fig. 2: *Siphonodella praesulcata* SANDBERG 1972. Steinberg Lst., upper *costatus*-Zone, Trolp Quarry (0,44 mm).

Figs. 3, 5: *Protognathodus collinsoni* ZIEGLER 1969. Steinberg Lst., *Protognathodus* Fauna, Trolp Quarry (0,76 mm).

Figs. 4, 6: *Protognathodus kockeli* (BISCHOFF 1957). Steinberg Lst., *Protognathodus* Fauna, Trolp Quarry (0,76 mm).

Figs. 7, 8: *Gnathodus antetexanus* REXROAD & SCOTT 1964. Upper Sanzenkogel Fm., *Scaliognathus anchoralis*-Zone, Section Weihermühle (0, 75 mm).

Figs. 9, 10: *Gnathodus antetexanus* REXROAD & SCOTT 1964. Upper Sanzenkogel Fm., *Scaliognathus anchoralis*-Zone, Section Hartbauer (0,95 mm).

Fig. 11: *Gnathodus typicus* COOPER 1939. Upper Sanzenkogel Fm., *Scaliognathus anchoralis*-Zone, Section Hartbauer (1,16 mm).

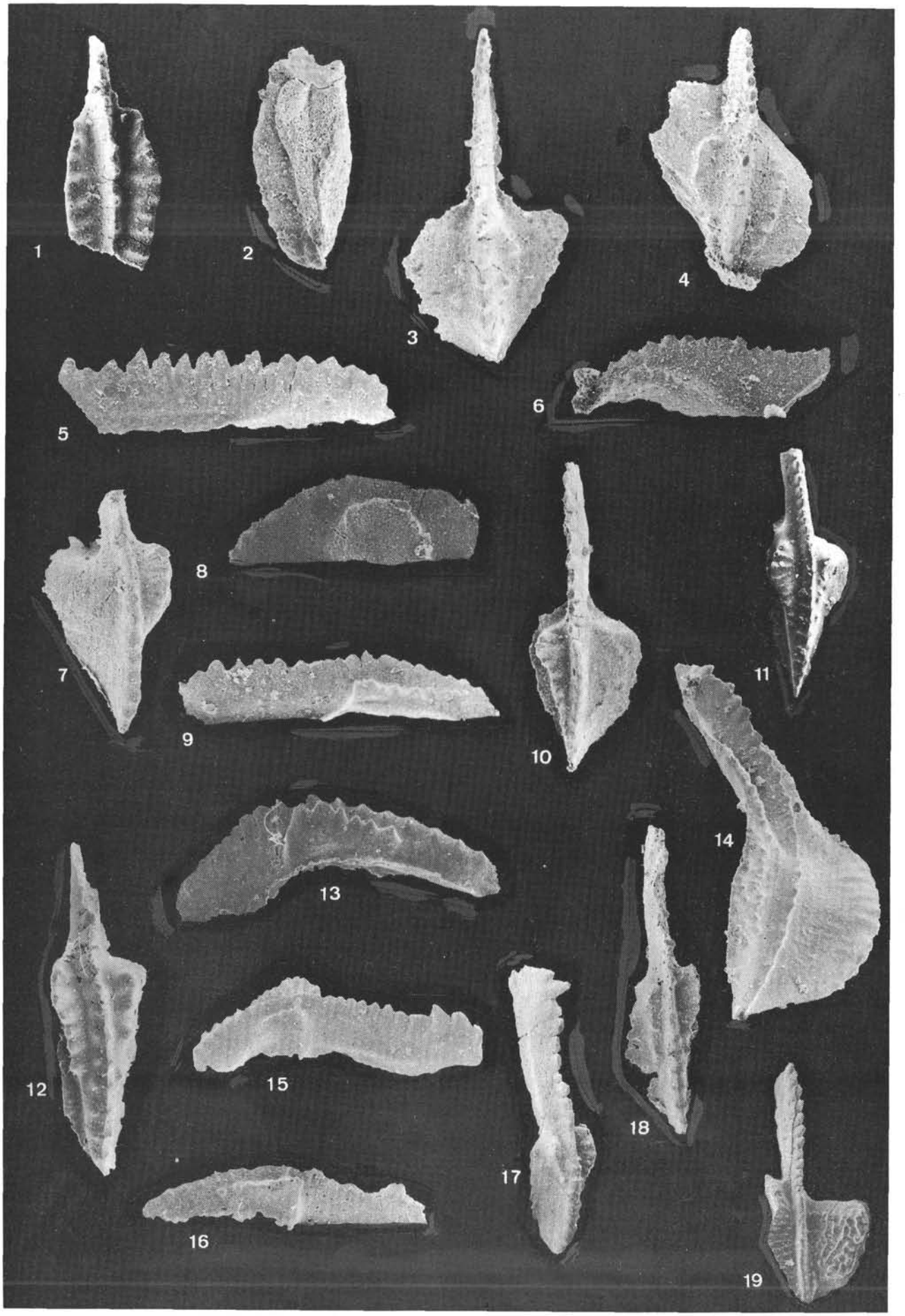
Figs. 12, 13: *Gnathodus typicus* COOPER 1939. Upper Sanzenkogel Fm., *Scaliognathus anchoralis*-Zone, Section Hartbauer (0,88 mm).

Fig. 14: *Siphonodella crenulata* (COOPER 1939) MT 2 SANDBERG et al. 1978. Upper Sanzenkogel Fm., *Scaliognathus anchoralis*-Zone, Trolp Quarry (1,02 mm).

Figs. 15, 17: *Gnathodus texanus* ROUNDY 1926. Upper Sanzenkogel Fm., *Scaliognathus anchoralis*-Zone, Section Weihermühle (1,46 mm).

Figs. 16, 18: *Gnathodus texanus* ROUNDY 1926. Upper Sanzenkogel Fm., *Scaliognathus anchoralis*-Zone, Section Hartbauer (1,56 mm).

Fig. 19: *Gnathodus bilineatus bilineatus* (ROUNDY 1926). Upper Sanzenkogel Fm., *Gnathodus commutatus nodosus*-Zone, Section Hahngraben (1,2 mm).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