acta
geologica
polonica

Vol. 35, No. 1-2 Warszawa 1985

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Lower Carboniferous conodont biostratigraphy in the northeastern part of the Moravia-Silesia Basin

ABSTRACT: The conodont fauna contained in carbonate rocks pierced by boreholes in the area between Olkusz and Sosnowiec (southern Poland) is recognized as indicative of Middle Tournaisian to late Viséan age. The three new species of *Gnathodus* and *Paragnathodus*, viz. *Gnathodus austini* sp. n., *Gnathodus praebilineatus* sp. n., and *Paragnathodus cracoviensis* sp. n., provide a clear understanding of the origin of Viséan gnathodid conodonts. To correlate the Lower Carboniferous deposits in the Olkusz and Sosnowiec area, the preliminary standard conodont zonation of SANDBERG & *al.* (1978) and LANE, SANDBERG & ZIEGLER (1980) is adpoted, and two conodont zones, the *austini* and the *bilineatus*, are introduced to extend the zonal scheme upward to the late Viséan. On the basis of this biostratographic framework, the diachronous nature of the facies is indicated, and this precludes simple correlation of lithological and biostartigraphic units. The significant stratigraphic gap between the Devonian and the Lower Carboniferous deposits covers the interval between the Middle and/or Upper *costatus* Zone (uppermost Famennian) and the *crenulata* Zone (Middle Tournaisian). In some places, however, the presence of the *sandbergi* Zone at the base of the Lower Carboniferous sequence is also suggested.

INTRODUCTION

The Lower Carboniferous sequence of the northeastern peripheral part of the Moravia-Silesia Basin is almost completely covered by Mesozoic and Tertiary deposits. In the Krzeszowice region, there occur many outcrops of the Lower Carboniferous strata (Text-fig. 1) that for a long time have extensively been studied by a number of workers, and the conodonts have been reported from several localities (GROMCZAKIEWICZ-ŁOMNICKA 1974, 1979; BEŁKA 1982).

By comparison, the recognition of the Lower Carboniferous sequence noted to occur below the Triassic cover near Olkusz was limited to the data from two boreholes only (ALEXANDROWICZ & ALEXANDROWICZ 1960; MATYJA & NARKIEWICZ 1979). In this area, over a hundred boreholes have recently been drilled in search for lead- and zinc-bearing Triassic deposits, but some of them pierced also the Lower Carboniferous strata. Based on these boreholes, the Dinantian carbonates have been recognized in the Sosnowiec and Olkusz areas (BEŁKA 1984, 1985). The facies analysis correlated by conodont zonation allowed to distinguish the carbonate platform, the platform margin, the foreslope, and the basinal facies. The biostratigraphic framework of that analysis is presented herein as well as the description of the conodont fauna which was collected from eigth boreholes (*cf.* Text-fig. 1). The list of samples and their conodont content have been enclosed in the earlier paper of the author (BEŁKA 1984).

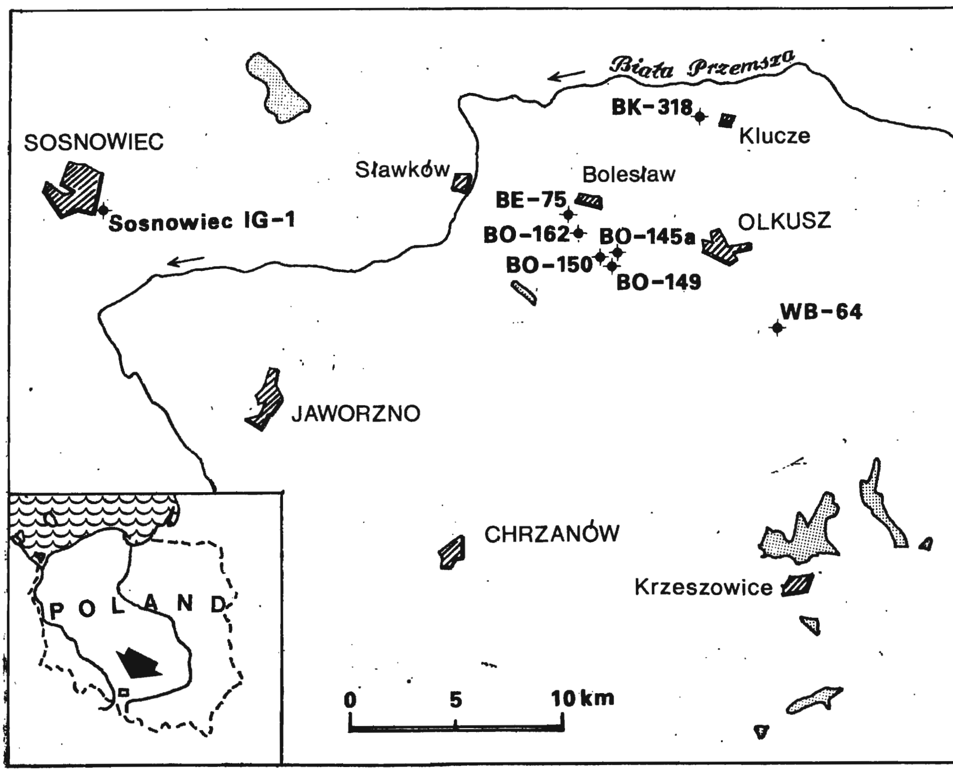


Fig. 1. Generalized location of the studied boreholes (*black circles*) and the outcrops of the Lower Carboniferous deposits (*stippled*) in the Olkusz and Sosnowiec area, northeastern part of the Moravia-Silesia Basin

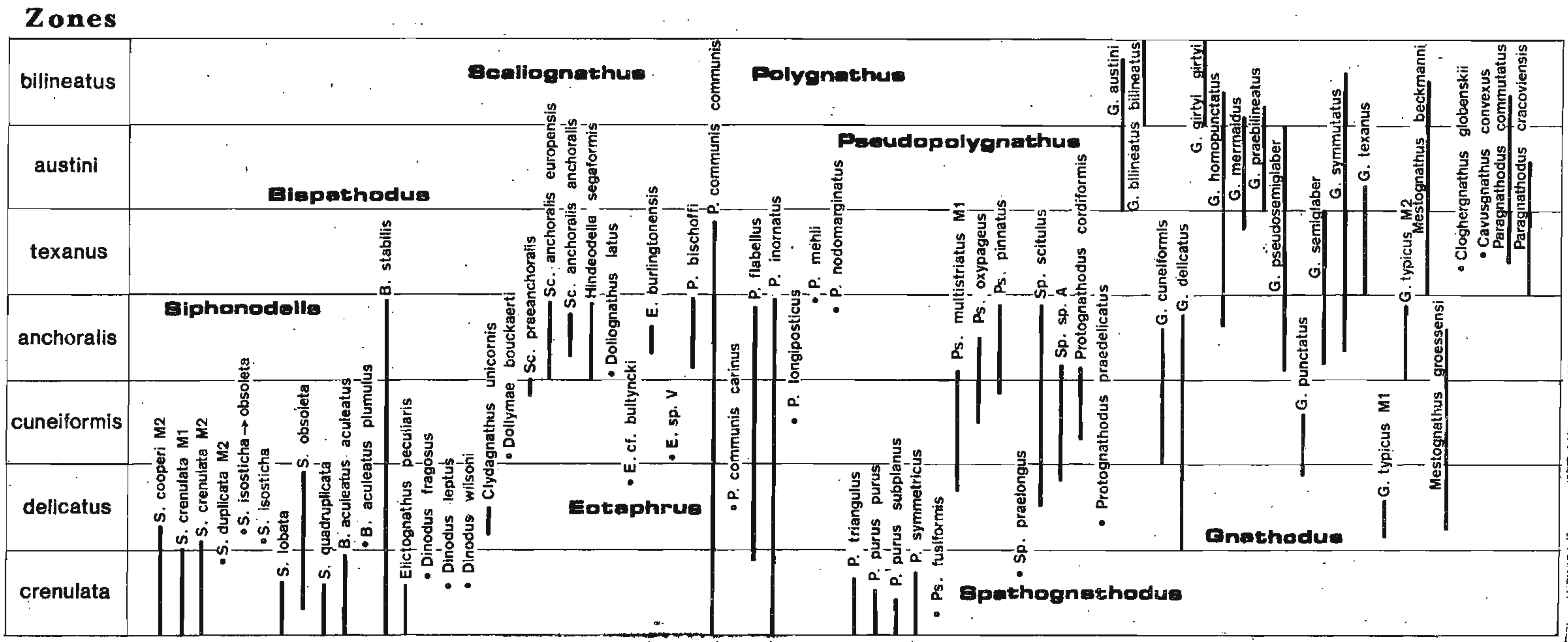
CONODONT FAUNA MATERIAL

In the present study over 300 samples have been processed, but only 178 yielded identifiable conodonts. Because of small diameter of cores, the weight of samples taken was from 0.5 to 1.5 kilogram. A total of about 2400 Lower Carboniferous conodonts were recovered, and the number of disjunct platform elements was almost 1600.

Moreover, four boreholes were also sampled for the Devonian conodonts (2000 elements from 12 samples) to define the age of the top of the Devonian sequence in the area between Olkusz and Sosnowiec.

The average number of conodonts per kilogram of rock dissolved was low, with a range from 7—10 (*cf.* BEŁKA 1984). Such relatively low conodont frequency is very common in the Carboni-

Distribution of conodont species in the Lower Carboniferous of the Olkusz and Sosnowiec area



ferous Limestone facies in Europe (*cf.* RHODES, AUSTIN & DRUCE 1969). It is usually interpreted as a result of rapid sedimentation (LINDSTRÖM 1964), but a relative decrease of conodont--bearing animals in the Lower Carboniferous seas should be also considered.

Both in the Lower Carboniferous and the Devonian samples the platform elements outnumber the ramiform ones. This is the case often observed in the majority of sections in the world and generally, it resulted from synsedimentary selective transport of particular conodont elements. ZIEGLER (1972) noted that the observations of thousands of the Upper Devonian samples displayed an almost regular ratio, four to one, between platform and ramiform elements. In the collected Lower Carboniferous material this ratio averages 1.5: 1 (Text-fig. 2). Nevertheless, the number of ramiform elements is still much too small. This is indicated by composition of natural conodont assemblages (*cf.* SCHMIDT 1934; SCHMIDT & MÜLLER 1964) and of reconstructed conodont apparatuses (KLAPPER & PHILIP 1971; CHAUFF 1981; HOROWITZ & REXROAD 1982), which show that the ramiform elements prevailed several times the platform ones. The more so that there were Lower Carboniferous conodont apparatuses (*see* BAESEMANN 1973) wanting in platform elements, e.g. *Idioprioniodus conjunctus* (GUNNELL). In the case under study, the synsedimentary, posthumous transport of conodonts seems most likely to be responsible for the artificial proportion of the both conodont elements in the samples. This is becuase that transport of allochems played an important part in the sedimentation of the Lower Carboniferous deposits near

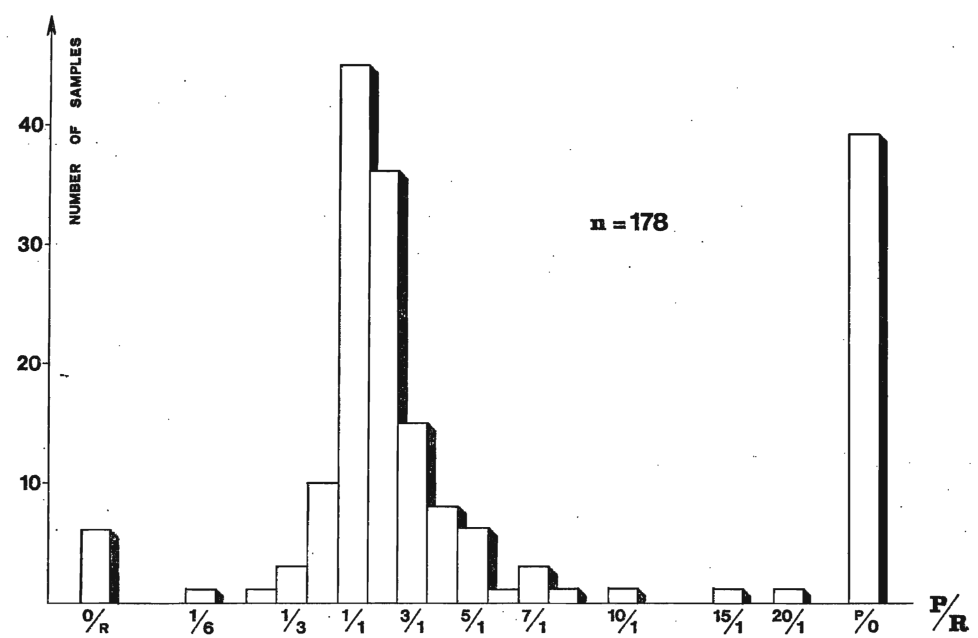


Fig. 2. Frequency distribution of the ratio between platform (*P*) and ramiform elements (*R*) in the 178 Lower Carboniferous samples from the Olkusz and Sosnowiec area

Olkusz and Sosnowiec (BEŁKA 1984, 1985). Even so, however, no mixed faunas were produced due to rapid sediment accumulation.

Considering the biostratigraphic purposes as well as the deficit of ramiform elements in the samples, the form taxonomy has been employed, and except a few ramiform elements (e.g. *Hindeodella segaformis*), only platform conodonts have thoroughly been investigated.

The collected conodont fauna, in term of its diversity, is very similar to those known from the United States, Spain, West Germany, and Belgium, which were noted to occur in offshore settings from the platform margin, the foreslope, and the basin (VOGES 1959; SANDBERG & GUTSCHICK 1979; LANE, SANDBERG & ZIEGLER 1980; HIGGINS & WAGNER-GENTIS 1982).

In the studied fauna, however, the observed abundance of conodonts, except of genus *Scaliognathus*, is distinctly lower; even the samples taken from the foreslope deposits did not yield an abundance as high as that reported by SANDBERG & GUTSCHICK (1979) in the Osagean fauna from Utah. The appearance of *Mestognathus*, represented by *M. groessensi*, much earlier than the base of the Lower Viséan makes the main difference of the studied fauna. Among the Tournaisian forms, such genera as *Doliognathus*, *Dollymae*, *Eotaphrus*, and *Protognathodus*, were found in very small quantities. The Viséan elements are characterized, however, by the great diversity of gnathodids, among which there appear three new species, viz. *Gnathodus austini* sp. n., *Gnathodus praebilineatus* sp. n., and *Paragnathodus cracoviensis* sp. n.

Some few specimens of *Mestognathus*, *Cavusgnathus* and *Cloghergnathus* in the counted fauna are a matter of course when the deep-water conditions of sedimentation during the Viséan are considered (BEŁKA 1984).

The stratigraphic ranges of the recognized Tournaisian and Viséan species (Text-fig. 3) are consistent with the data from other continents (*cf.* LANE, SANDBERG & ZIEGLER 1980). Two taxa only, *Gnathodus pseudosemiglaber* and *Eotaphrus? sp. V*, make their first appearance earlier than it has hitherto been known.

The morphotypes of the species of *Siphonodella* and *Gnathodus* recognized herein were originally distinguished by SANDBERG & *al.* (1978) and LANE, SANDBERG & ZIEGLER (1980).

PLATE 1

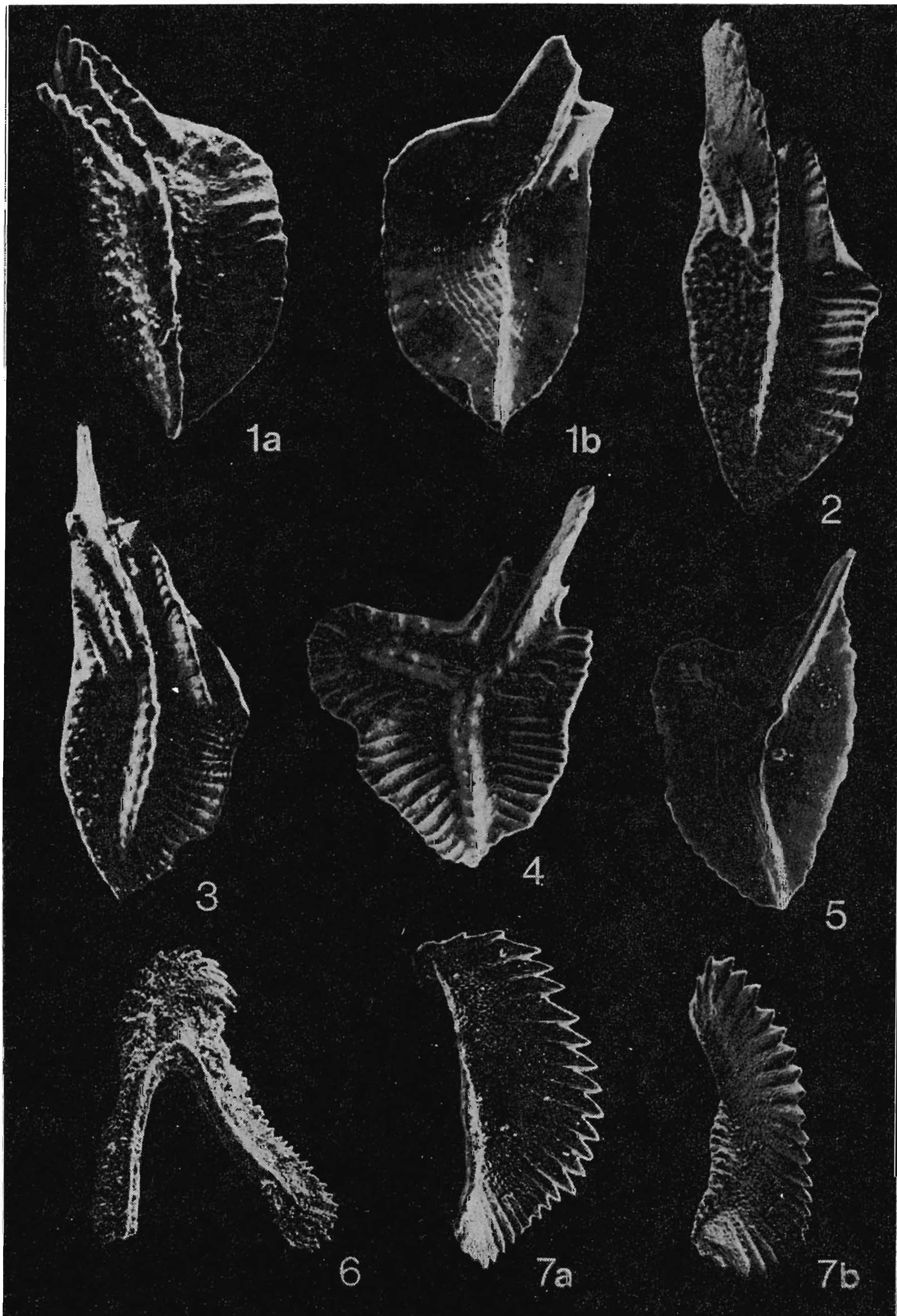
1 — *Siphonodella crenulata* (COOPER, 1939), Morphotype *2*; borehole WB-64 (depth 158 m), **1a** — upper view, ×84; **1b** — lower view, ×77

2-3 — *Siphonodella quadruplicata* (BRANSON & MEHL, 1934); *2* from BO-150 (depth 567 m), upper view, ×57; *3* from BO-150 (depth 567 m), upper view, ×37

4-5 — *Siphonodella lobata* (BRANSON & MEHL, 1934); *4* from BO-150 (depth 563.2 m), upper view, ×34; *5* from BO-150 (depth 564.3 m), juvenile specimen, lower view, ×79

6 — *Dinodus leptus* COOPER, 1939; BO-150 (depth 563.2 m), lateral view, ×45

7 — *Elictognathus peculiaris* (BRANSON & MEHL, 1934); BO-150 (depth 564.3 m), **7a** — lateral view, ×73; **7b** — oblique upper view, ×78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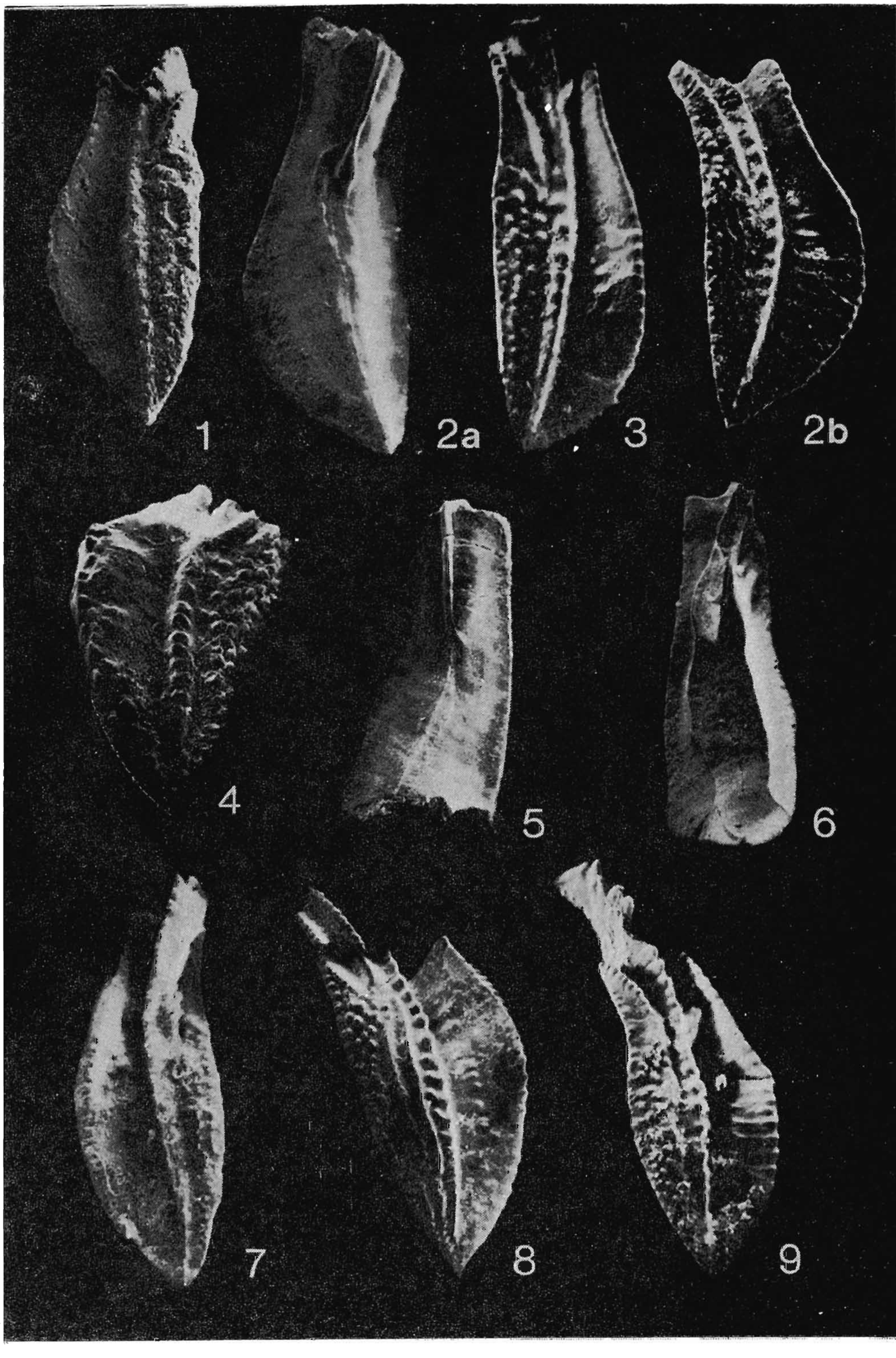
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SYSTEMATIC ACCOUNT

The systematic part includes a description of 3 new species of *Gnathodus* and *Paragnathodus*, and a discussion upon two species. The other species present in the collected fauna are only listed (Text-fig. 3) and illustrated (Pls 1—17). All type material and figures specimens are kept in the collection of the Institute of Geology, University of Warsaw.

Genus *Eotaphrus* PIERCE & LANGENHEIM, 1974

Type species: *Eotaphrus burlingtonensis* PIERCE & LANGENHEIM, 1974

Eotaphrus? sp. *V* of LANE, SANDBERG & ZIEGLER, 1980
(Pl. 9, Fig. 6)

1959. *Icriodus latericrescens* BRANSON & MEHL?; VOGES, p. 286 (specimens not illustrated).
1971. N. GEN. B; GROESSENS, p. 17, Pl. 2, Figs 5—6
1980. *Eotaphrus*? n. sp. *V*; LANE, SANDBERG & ZIEGLER, Pl. 10, Figs 9—10 (specimens from VOGES' collection).

MATERIAL: 1 specimen.

REMARKS: As presently conceived (LANE, SANDBERG & ZIEGLER 1980), the genus *Eotaphrus* contains three species forming a phyletic lineage *E. evae*→*E. bultyncki*→*E. burlingtonensis*, and *Eotaphrus*? sp. *V* is referred as a possible fourth species of this genus. The latter form has a close resemblance to *E. burlingtonensis* PIERCE & LANGENHEIM but differs from all the former species of *Eotaphrus* by having a very weak cusp at the anterior end*. The presented specimen (Pl. 9, Fig. 6) was found in the lower part of the *cuneiformis* Zone, *i.e.* much earlier (*cf.* LANE, SANDBERG & ZIEGLER 1980) than the first occurrence of *Eotaphrus evae*. Although the general shape and morphology coincide with the diagnosis of the genus *Eotaphrus*, this element seems to be more closely connected with genus *Staurognathus*. The transitional form described by AUSTIN & GROESSENS (1972) as „New genus *B* GROESSENS→*Staurognathus* BRANSON & MEHL" shows that *Eotaphrus*? sp. *V* could be the ancestor of *Staurognathus cruciformis* BRANSON & MEHL.

RANGE: At present, known from lower parts of the *cuneiformis* Zone and of the *anchoralis* Zone.

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* All representatives of the genus *Eotaphrus* are herein oriented inversely than hitherto given. This follows NICOLL's suggestion (1982) that genus *Icriodus*, which is homeomorphic with *Eotaphrus*, was previously oriented incorrectly. Basing on a study of ontogeny of *Icriodus expansus*, NICOLL (1982) noted that the posterior cusp of icriodid platform elements was homologous to the anterior blade in such platform elements as *Polygnathus*, *Gnathodus* and *Siphonodella*. This is why all the *Icriodus*-like platform elements are to be reoriented.

PLATE 2

1-3 — *Siphonodella isosticha*→*obsoleta*; *1* from Sosnowiec (depth 1887 m), ×70; *2* from Sosnowiec (depth 1909.6 m), 2a — lower view, ×51; 2b — ×47; *3* from Sosnowiec (depth 1909.6 m), ×63

4-9 — *Siphonodella obsoleta* HASS, 1959; *4* from Sosnowiec (depth 1889 m), ×41; *5* from Sosnowiec (depth 1912 m), lower view, ×41; *6* from Sosnowiec (depth 1912 m), lower view of the platform with well-developed pseudokeel, ×66; *7* from Sosnowiec (depth 1911 m), ×47; *8* from BO-150 (depth 525 m), ×50; *9* from BO-150 (depth 558 m), ×60

All upper views, except as noted

Genus *Gnathodus* PANDER, 1856
Type species: *Gnathodus mosquensis* PANDER, 1856
Gnathodus austini sp. n.
(Pl. 4, Figs 2—3, 7—8 and 10—11)

1967. *Gnathodus texanus* ROUNDY; WIRTH, p. 213, Pl. 23, Fig. 19 (only).
1977. *Gnathodus texanus* ROUNDY; PERRET, Pl. 51, Fig. 16a—b.
1977. *Gnathodus typicus* COOPER; EBNER, pp. 470—471, Pl. 1, Fig. 8 (only).
1982. *Gnathodus girtyi*; von BITTER & PLINT-GEBERL, Pl. 6, Fig. 7 only.

HOLOTYPE: The specimen illustrated in Pl. 4, Fig. 11a—c.
DERIVATION OF THE NAME: In honour of Dr. Ronald L. AUSTIN, University of Southampton.
TYPE LOCALITY: Borehole *BO-162* (depth 353.8 m), 5 km west of Olkusz, Polish Jura.
TYPE HORIZON: The *austini* Zone (Middle Viséan)

DIAGNOSIS: A species of *Gnathodus* having on its inner side a parapet, the anterior portion of which forms either a high, single node or two fused nodes; the parapet does not extend to the posterior tip of the blade; the outer side of the cup bears, parallely to the blade, a row of a few nodes that both anteriorly and posteriorly is shorter than the parapet. The posterior blade denticles are generally simple.

MATERIAL: 17 specimens.

REMARKS: The species *Gnathodus austini* sp. n. covers the transitional field between *G. texanus* ROUNDY and *G. girtyi girtyi* HASS. These three taxa form an easily distinguishable phyletic lineage *G. texanus*→*G. austini*→*G girtyi girtyi* illustrating an increased platform development (*see* Pl. 4, Figs 1—9). The most diagnostic feature of *Gnathodus austini*, the high, simple node at the anterior end of the parapet is reminiscent of a pillar-like parapet present (*see* Pl. 4, Figs 1 and 5—6) in *G. texanus*. The successive connections of *G. austini* with its predecessor are shown by juvenile specimens that usually exibit an expanded posterior blade (Pl. 4, Fig. 10). The new species, *G. austini* sp. n. resembles *G. girtyi girtyi*, which can be distinguished, however, by the well-developed, both inner and outer parapets extending to the posterior tip of the blade (Pl. 4, Figs 4 and 9). Nevertheless, in the *bilineatus* Zone, juvenile specimens of these taxa are problematic in their discrimination.

This unit can also be mistaken for *Gnathodus typicus* Morphotype *2* (sensu LANE, SANDBERG & ZIEGLER 1980), but the latter form never yields so distinct high node at the anterior end of the parapet.

RANGE: From the base of the *austini* Zone into the *bilineatus* Zone.

PLATE 3

1-3 — *Gnathodus delicatus* BRANSON & MEHL, 1938; *1* from Sosnowiec (depth 1820.5 m), ×69; *2* from Sosnowiec (depth 1845.5 m), ×50; *3* from Sosnowiec (depth 1842.5 m), specimen transitional to *Gnathodus cuneiformis*, ×67

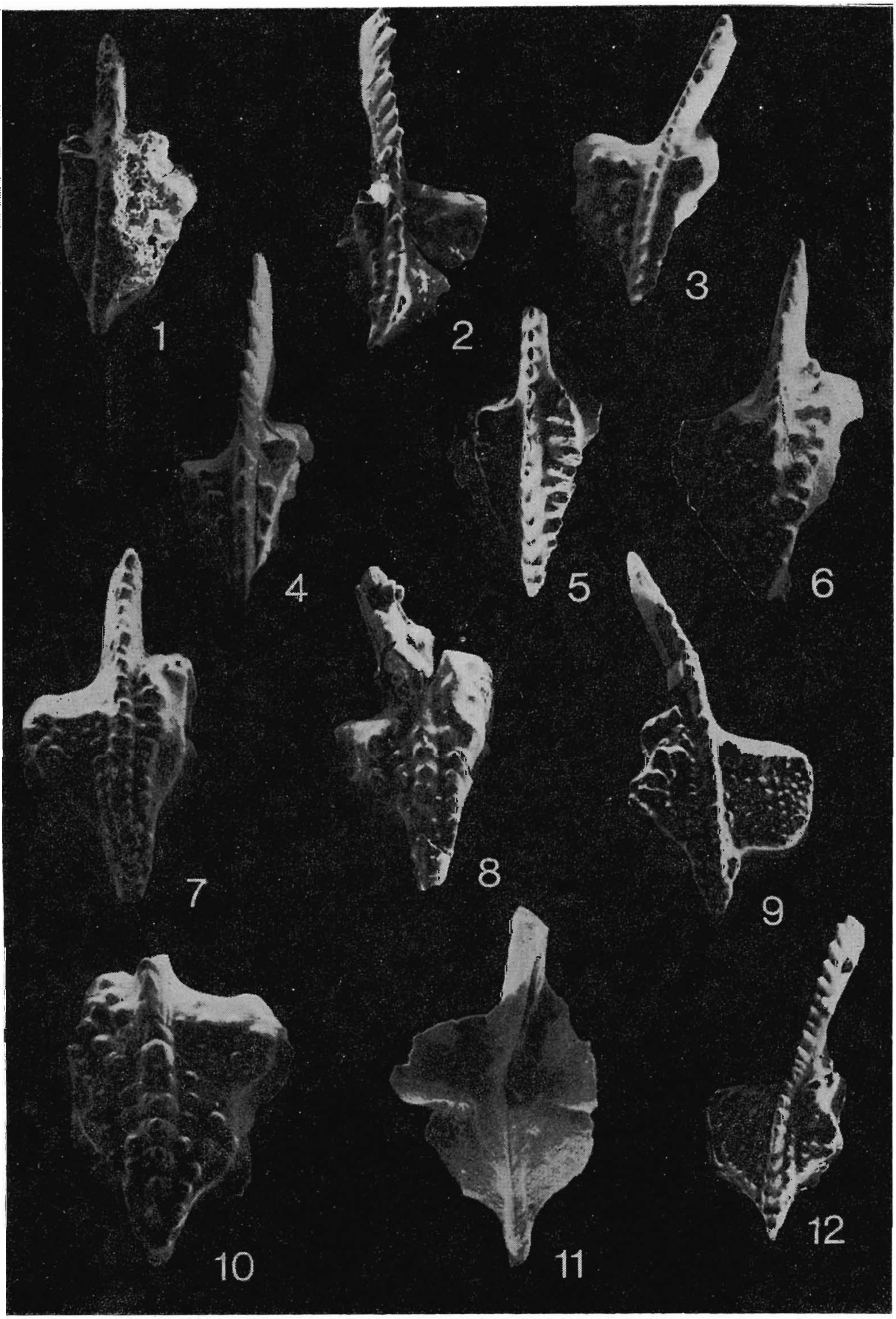
4-5, 7-8 — *Gnathodus cuneiformis* MEHL & THOMAS, 1947; *4* from Sosnowiec (depth 1854 m), juvenile specimen, ×94; *5* from BO-162 (depth 353.3 m), ×82; *7* from Sosnowiec (depth 1859 m), specimen transitional to *Gnathodus delicatus*, ×47: *8* from Sosnowiec (depth 1859 m), ×50

6 — *Protognathodus praedelicatus* LANE, SANDBERG & ZIEGLER, 1980; Sosnowiec (depth 1881.5 m), ×82

9, 12 — *Gnathodus punctatus* (COOPER, 1939); *9* from WB-64 (depth 111 m), ×27; *12* from WB-64 (depth 113 m), ×33

10-11 — *Protognathodus cordiformis* LANE, SANDBERG & ZIEGLER, 1980; *10* from Sosnowiec (depth 1842.5 m), ×59; *11* from Sosnowiec (depth 1842.5 m), lower view, ×61

All upper views, except Fig. 11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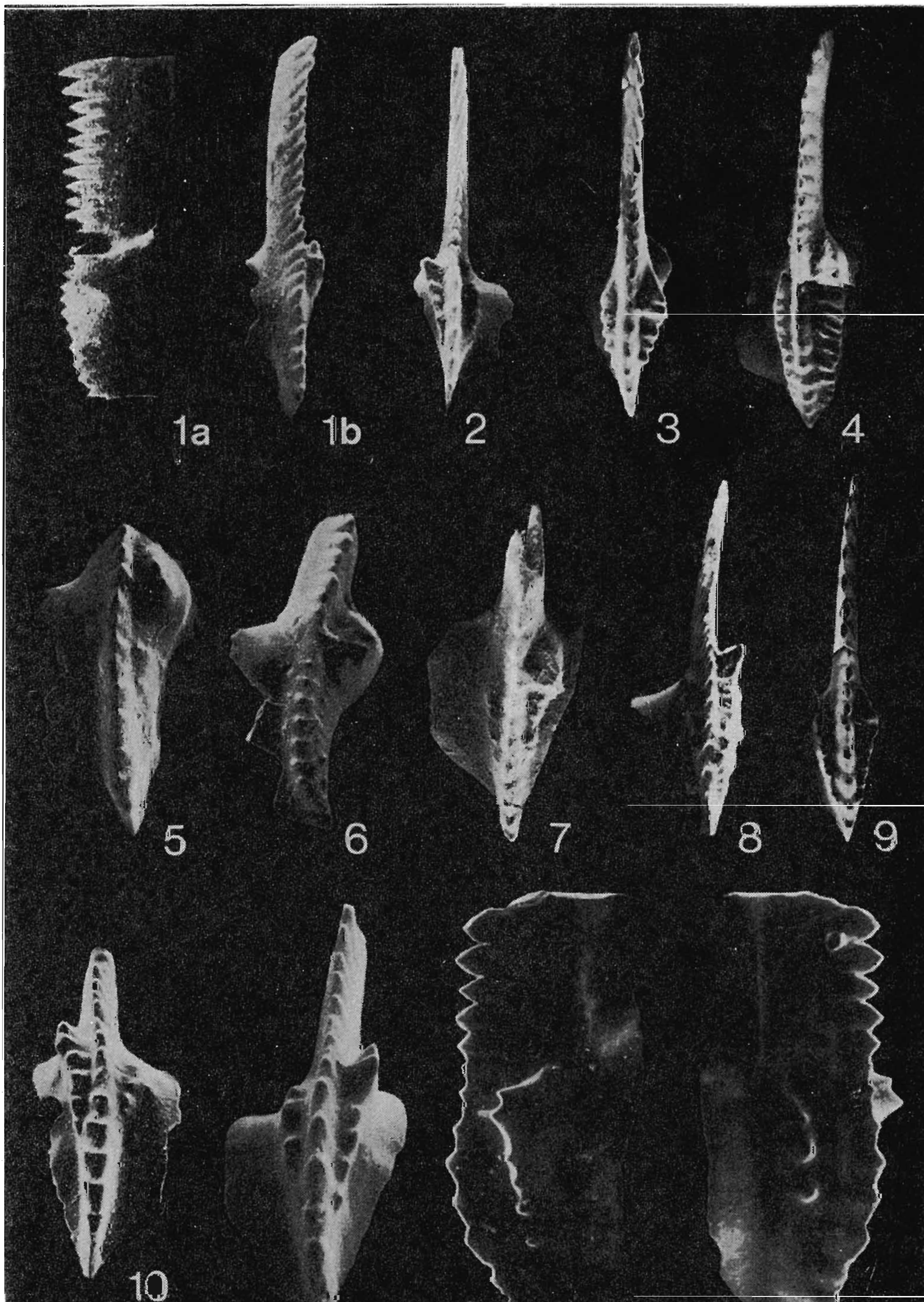
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Gnathodus praebilineatus sp. n.
(Pl. 7, Figs 4—8)

1974. *Gnathodus bilineatus* (ROUNDY); AUSTIN & HUSRI, Pl. 3, Figs 4—5 (only).
1977. *Gnathodus* sp. *A*; EBNER, p. 471, Pl. 2, Figs 5, 7—10, 13.
1982. *Gnathodus bilineatus*; von BITTER & PLINT-GEBERL, Pl. 6, Figs 8—11.
1982. *Gnathodus bilineatus bilineatus* (ROUNDY); HIGGINS & WAGNER-GENTIS, pp. 328—329 (second morphotype only).

HOLOTYPE: The specimen illustrated in Pl. 7, Fig. 4.
DERIVATION OF THE NAME: From the fact that this species precedes and is ancestral to *Gnathodus bilineatus.*
TYPE LOCALITY: Borehole *BE-75* (depth 448.5 m), 5.5 km west of Olkusz, Polish Jura.
TYPE HORIZON: The lower part of the *bilineatus* Zone (Middle-Upper Viséan).

DIAGNOSIS: A species of *Gnathodus* characterized by a broad, triangular cup with a long inner parapet formed by a row of nodes or cross ridges extending to, or near to the posterior tip of the blade; the outer cup is smooth or ornamented by randomly scattered nodes.

MATERIAL: 13 specimens.

REMARKS: The species *Gnathodus praebilineatus* sp. n. is a perfect homeomorph of *Gnathodus delicatus* BRANSON & MEHL, and it also appears to be homeomorphic with *Gnathodus bilineatus bollandensis* HIGGINS & BOUCKAERT. These three taxa, however, are separated by a disparity in their stratigraphic ranges (*cf.* HIGGINS 1975; LANE, SANDBERG & ZIEGLER 1980; BEŁKA 1984). The new species is clearly connected, by transitional specimens (Pl. 7, Fig. 8), to its descendant, *Gnathodus bilineatus bilineatus.* Quadrate shape of the outer cup that typically bears a row of nodes paralleling the blade in its posterior end, as well as a tendency for ornamentation to form rows of nodes or ridges allow, however, to recognize *G. bilineatus bilineatus.*

Most likely, *G. praebilineatus* evolved from *G. semiglaber* BISCHOFF by the development of the inner parapet and simultaneously by reduction of the posterior blade to become simple. The specimens described by EBNER (1977) as *Gnathodus* sp. *A* from the Lower Viséan of Styria represent the earliest phylogenetic forms of *G. praebilineatus*; their parapet is lower and do not extend to the posterior tip of the blade, whereas the outer cup may be almost smooth (*comp.* Pl. 7, Figs 5 and 7).

Recently, HIGGINS & WAGNER-GENTIS (1982) recognized two morphotypes of *Gnathodus bilineatus bilineatus* based on length of the inner parapet and the pattern of the outer cup ornamentation. The first morphotype has a long parapet and corresponds to the nominative subspecies, while in the second one the parapet is shorter. Unfortunately, only first of these morphotypes has been figured and, moreover, stratigraphic ranges of these morphotypes have not been subdivided. It is thought that the second morphotype corresponds exactly to *G. praebilineatus* sp. n. which is treated as a new species, and regarded as an ancestor of *G. bilineatus bilineatus.*

RANGE: Base of the *austini* Zone into the lower part of the *bilineatus* Zone.

PLATE 4

1, 5-6 — *Gnathodus texanus* ROUNDY, 1926; *1* from BO-162 (depth 366.5 m), **1a** — lateral view, ×33; **1b** — ×34; *5* from BO-149 (depth 216 m), ×58; *6* from BO-150 (depth 196.5 m), ×44

2-3, 7-8, 10-11 — *Gnathodus austini* sp. n.; *2* from BO-162 (depth 366.5 m), ×69; *3* from BO-162 (depth 354.8 m), ×82; *7* from BO-162 (depth 372 m), ×58; *8* from BO-162 (depth 354.8 m), ×58; *10* from BE-75 (depth 472.4 m), ×67; *11* from BO-162 (depth 353.8 m), holotype, **11a** — ×80; **11b** — lateral view to show the inner parapet, ×84; **11c** — lateral view to show the outer parapet, ×80

4, 9 — *Gnathodus girtyi girtyi* HASS, 1953; *4* from BE-75 (depth 448.5 m), ×43; 9 from BO-162 (depth 346.3 m), ×62

All upper views, except as noted

Genus *Paragnathodus* HIGGINS, 1975

Type species: *Spathognathodus commutatus* BRANSON & MEHL, 1941

Paragnathodus cracoviensis sp. n.

(Pl. 11, Figs 5—6)

1957. *Gnathodus commutatus commutatus* (BRANSON & MEHL); BISCHOFF, p. 23, Pl. 4, Figs 3—4, 6 (only).
1972. *Gnathodus commutatus commutatus*; CHOROWSKA, Pl. 1, Figs 12—13.
1973. *Gnathodus* cf. *G. commutatus commutatus* BISCHOFF; CONIL, GROESSENS & LYS, Pl. 6, Figs 24—25.
1974. *Gnathodus commutatus* (BRANSON & MEHL); AUSTIN & *al.*, Pl. 1, Fig. 12 (only).
1974. *Gnathodus commutatus commutatus* (BRANSON & MEHL); AUSTIN & HUSRI, Pl. 2, Fig. 2a—c (only).
1974. *Gnathodus* cf. *commutatus*; GROESSENS, p. 167, Pl. 46.
1979. *Gnathodus* sp./ aff. *Paragnathodus commutatus* (BRANSON & MEHL); MATYJA & NARKIEWICZ, p. 485, Pl. 4, Figs 1—2, 5.
1980. *Gnathodus commutatus* (BRANSON & MEHL); METCALFE, Pl. 13, Fig. 10.

HOLOTYPE: The specimen illustrated in Pl. 11, Fig. 6a—b.
DERIVATION OF THE NAME: After Cracow, the old capital of Poland.
TYPE LOCALITY: Borehole Sosnowiec *IG-1* (depth 1779 m) in Upper Silesia.
TYPE HORIZON: The *texanus* Zone (Lower Viséan).

DIAGNOSIS: A species of *Paragnathodus* characterized by a broad blade that is expanded to form transverse ridges; the blade tapers posteriorly and anteriorly alike, and extends beynod the oval-shaped cup at the posterior end.

MATERIAL: 7 specimens

REMARKS: The species *Paragnathodus cracoviensis* sp. n., due to having a smooth cup, closely resembles *Paragnathodus commutatus* (BRANSON & MEHL) which can be distinguished, however, by its simple, unexpanded blade and a more circular shape of the cup. The juvenile specimens of these two species may be indistinguishable, because, as noted by HIGGINS (1975), the juvenile forms of *P. commutatus* tend to have an expanded blade and a rather narrow cup. MATYJA & NARKIWEICZ (1979) considered, therefore, the adult specimens characterized by expanded blade, described as „*Gnathodus* sp. /aff.*Paragnathodus commutatus* (BRANSON & MEHL)" to be a predecessor of *P. commutatus*. The species *P. cracoviensis* sp. n., as an ancestor of *P. commutatus*, is thus the earliest species of the genus. Most likely, it evolved at the base of the *texanus* Zone from *Bispathodus stabilis*, a long-ranging conservative species, which also gave rise to the genus *Protognathodus* (*see* ZIEGLER, SANDBERG & AUSTIN 1974) which is considered to be homeomorphic with *Paragnathodus*.

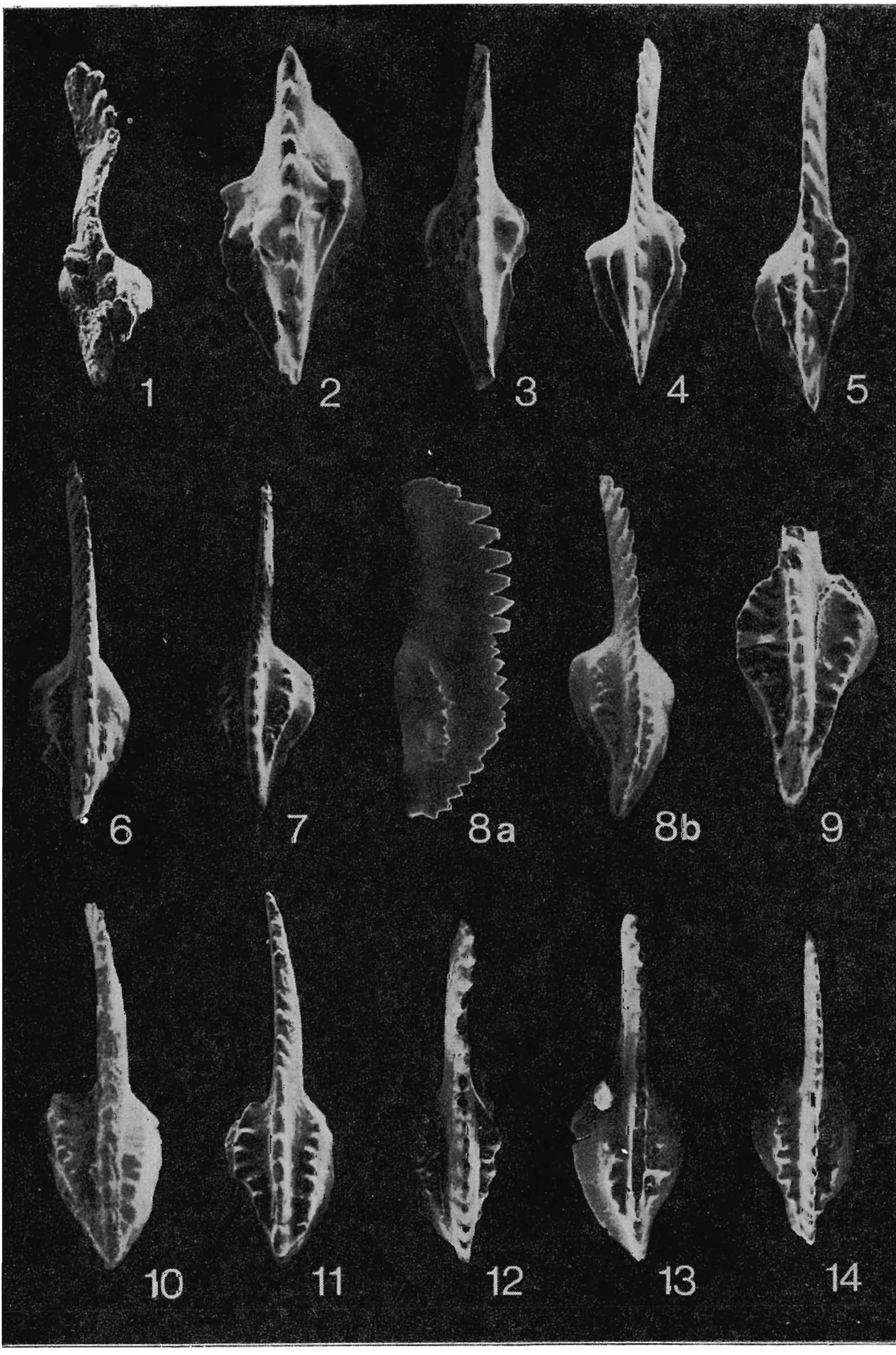
RANGE: From the base of the *texanus* Zone into the lower part of the *austini* Zone. The specimen of *G. commutatus* reported from the uppermost Viséan of Tramaka, Belgium (AUSTIN & *al.* 1974, Pl. 1, Fig. 12), and treated herein as *P. cracoviensis*, has most certainly been redeposited; in other sections in Belgium, the forms attributable to *P. cracoviensis* sp. n. are noted from the Lower Viséan only (*cf.* GROESSENS 1974).

PLATE 5

1-5 — *Gnathodus typicus* COOPER, 1939; *1* from Sosnowiec (depth 1887 m), Morphotype *1*, ×65; *2* from WB-64 (depth 143.7 m), Morphotype *2*, ×91; *3* from BO-150 (depth 407 m), Morphotype *2*, ×70; *4* from BO-150 (depth 421 m), Morphotype *2*, juvenile specimen, ×93; *5* from BO-150 (depth 411 m), Morphotype *2*, juvenile specimen, ×100

6-14 — *Gnathodus homopunctatus* ZIEGLER, 1962; *6* from BE-75 (depth 472.4 m), ×55; *7* from Sosnowiec (depth 1776.4 m), ×65; *8* from Sosnowiec (depth 1762 m), ×47, 8**a** — lateral view, 8**b** — upper view, *9* from BO-150 (depth 361 m), ×60; *10* from Sosnowiec (depth 1700.5 m), ×43; *11* from BE-75 (depth 448.5 m), ×61; *12* from BO-162 (depth 346.3 m), ×80; *13* from BO-162 (depth 346.3 m), ×76; *14* from BO-162 (depth 356.8 m), ×54

All upper views, except Fig. 8a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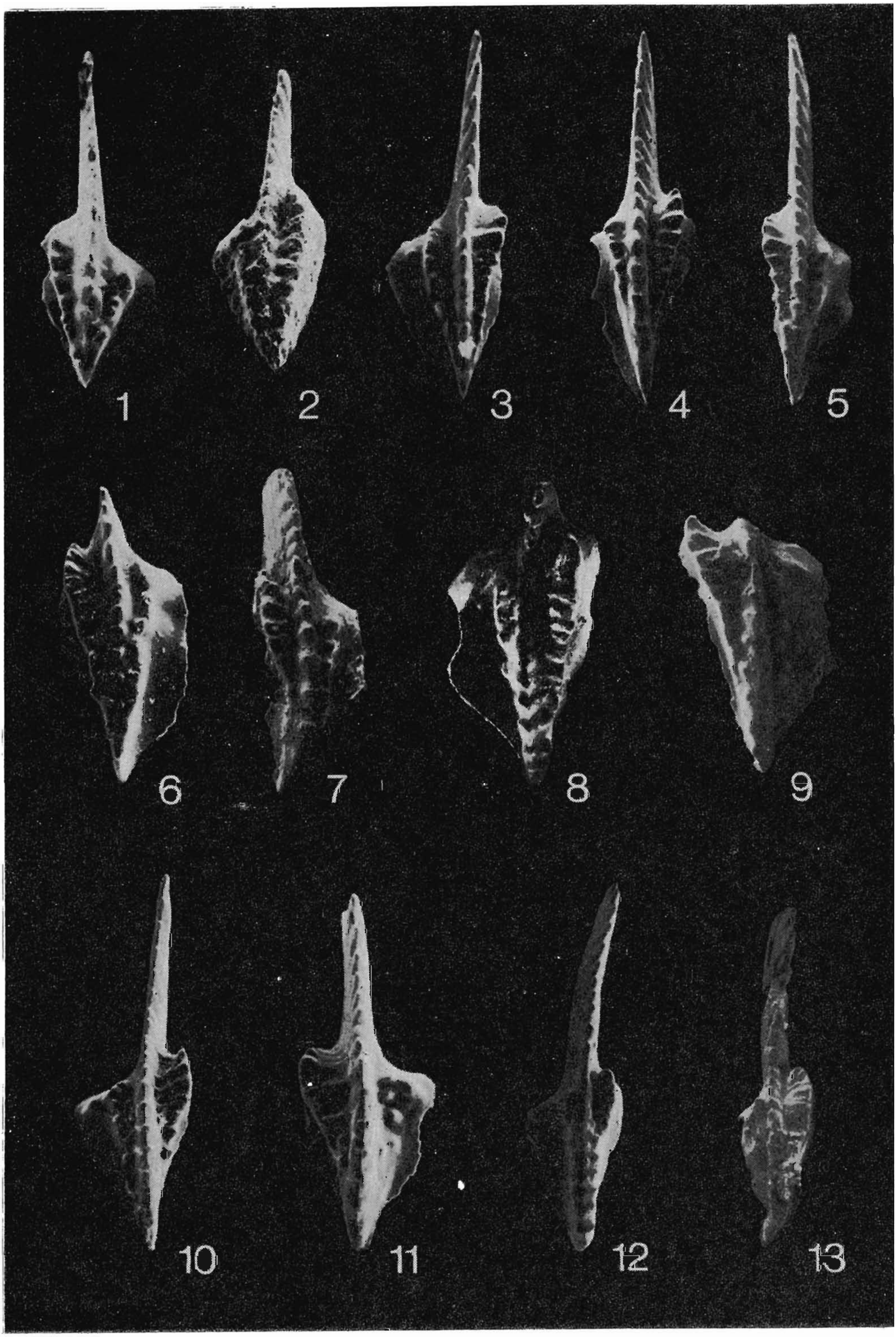
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Genus *Polygnathus* HINDE, 1879
Type species: *Polygnathus dubius* HINDE, 1879
Polygnathus triangulus (VOGES, 1959)
(Pl. 13, Figs. 2—4)

1959. *Pseudopolygnathus triangula triangula* n. subsp.; VOGES, pp. 304—305, Pl. 35, Figs 7—13.
1961. *Pseudopolygnathus triangula triangula* VOGES; FREYER *in*: DVORAK & FREYER, p. 894, Pl. 2, Figs 6—7.
1966. *Pseudopolygnathus triangula triangula* VOGES; KLAPPER, p. 13, Pl. 1, Figs 15—22.
1969. *Pseudopolygnathus triangula triangula* VOGES; SCHÖNLAUB, p. 341, Pl. 1, Figs 20—22.
1969 *Pseudopolygnathus triangula triangula* VOGES; MATTHEWS, p. 271, Pl. 48, Figs 2 and 7.
1970. *Pseudopolygnathus triangulus triangulus* VOGES; THOMPSON & FELLOWS, p. 103, Pl. 7, Figs 6—7.
1973. *Pseudopolygnathus trangulus triangulus* VOGES; BUTLER, p. 510, Pl. 58, Fig. 32.
1974. *Pseudopolygnathus triangulus triangulus* VOGES; GEDIK, p. 24, Pl. 6, Figs 3 and 9.

MATERIAL: 5 specimens.

REMARKS: This unit was formely assigned to the genus *Pseudopolygnathus*. It was KLAPPER (1966) who first noticed that only immature specimens of *Pseudopolygnathus triangulus triangulus* VOGES display a relatively large basal cavity being diagnostic of the genus *Pseudopolygnathus*, whereas in the majority of specimens the basal cavity is very small and it forms a pit similar to that of genus *Polygnathus*. Because these two genera are separated, first of all, on the basis of the basal cavity size, the species *Pseudopolygnathus triangulus triangulus* is transfered herein (*cf. also* LANE, SANDBERG & ZIEGLER 1980) to the genus *Polygnathus*.

RANGE: In the investigated sections this taxon occurs only in the lower part of the *crenulata* Zone.

CONODONT ZONATION

In the past tens of years the conodonts have become a commonly accepted tool for the Lower Carboniferous biostratigraphy. As a consequence, dozens of conodont zonations have been proposed, the most important of which are these of VOGES (1959, 1960), COLLINSON, SCOTT & REXROAD (1962), HIGGINS & BOUCKAERT (1968), MEISCHNER (1970), MARKS & WENSINK (1970), COLLINSON, REXROAD & THOMPSON (1971), PIERCE & LANGENHEIM (1972), AUSTIN (1973), AUSTIN & HUSRI (1974), GROESSENS (1974), HIGGINS (1974), JENKINS (1974), RICE & LANGENHEIM (1974), EBNER (1977), PERRET (1977), BUCHROITHNER (1979), RUPPEL (1979), SANDBERG (1979), JOHNSTON & HIGGINS (1981), HIGGINS & VARKER (1982), and von BITTER

PLATE 6

1 — *Gnathodus delicatus*→*cuneiformis*; WB-64 (depth 154.2 m), ×68
2-3 — *Gnathodus cuneiformis* MEHL & THOMAS, 1947; *2* from WB-64 (depth 120 m), ×61; *3* from BO-150 (depth 389 m), ×73
4 — *Gnathodus cuneiformis*→*pseudosemiglaber*; BO-150 (depth 411 m), juvenile specimen, ×106
5-13 — *Gnathodus pseudosemiglaber* THOMPSON & FELLOWS, 1970; *5* from Sosnowiec (depth 1762 m), ×45; *6* from BO-150 (depth 421 m), ×51; *7* from Sosnowiec (depth 1779 m), ×63; *8* from BE-75 (depth 456 m), ×40; from Sosnowiec (depth 1762 m), ×46; *10* from BO-150 (depth 411 m), ×69; *11* from BO-150 (depth 411 m), juvenile specimen, ×95; *12* from BO-150 (depth 359 m), ×25; *13* from Sosnowiec (depth 1787 m), ×20

All upper views

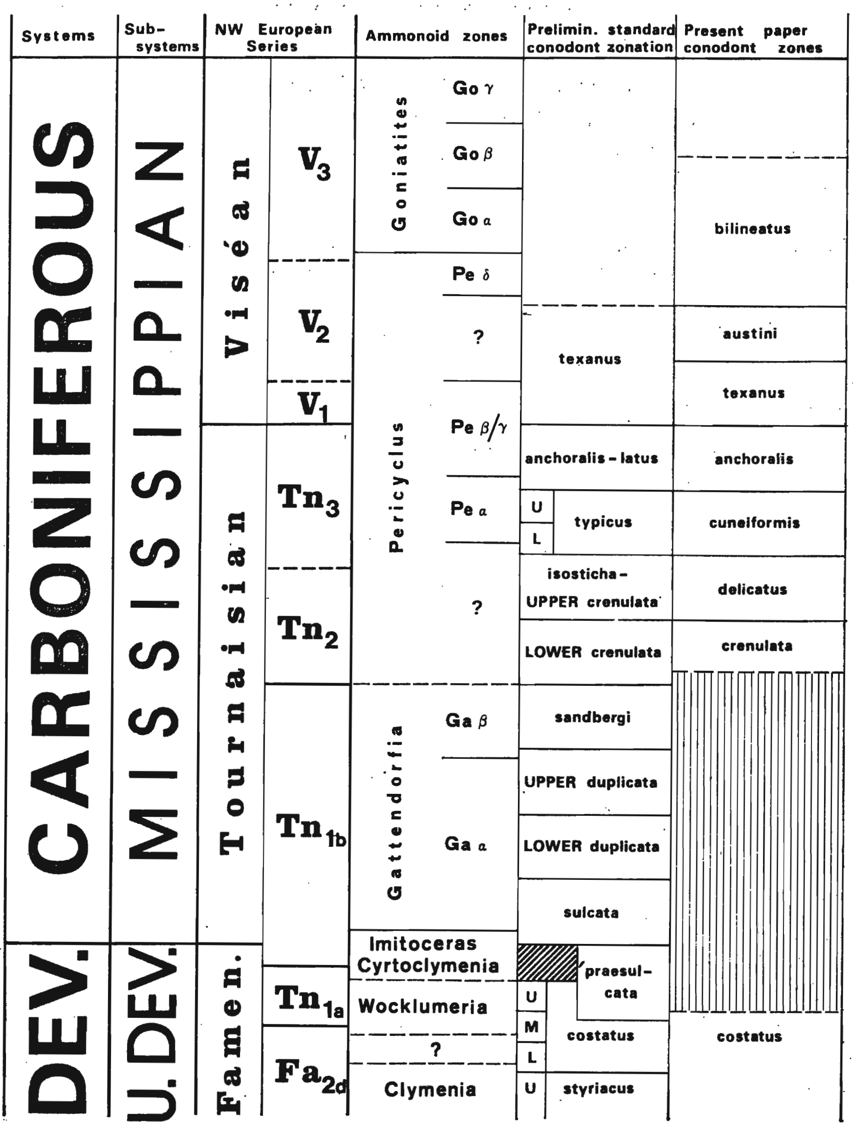


Fig. 4. Correlation of the proposed conodont zonal scheme and the preliminary standard zonation with the ammonoid sequence (*based on*: VOGES 1960, MEISCHNER 1970, *and* SANDBERG & *al.* 1978) and the Belgian stratigraphic scheme (*based on*: CONIL & PAPROTH 1968, GROESSENS 1974, *and* CONIL, GROESSENS & PIRLET 1976)

PLATE 7

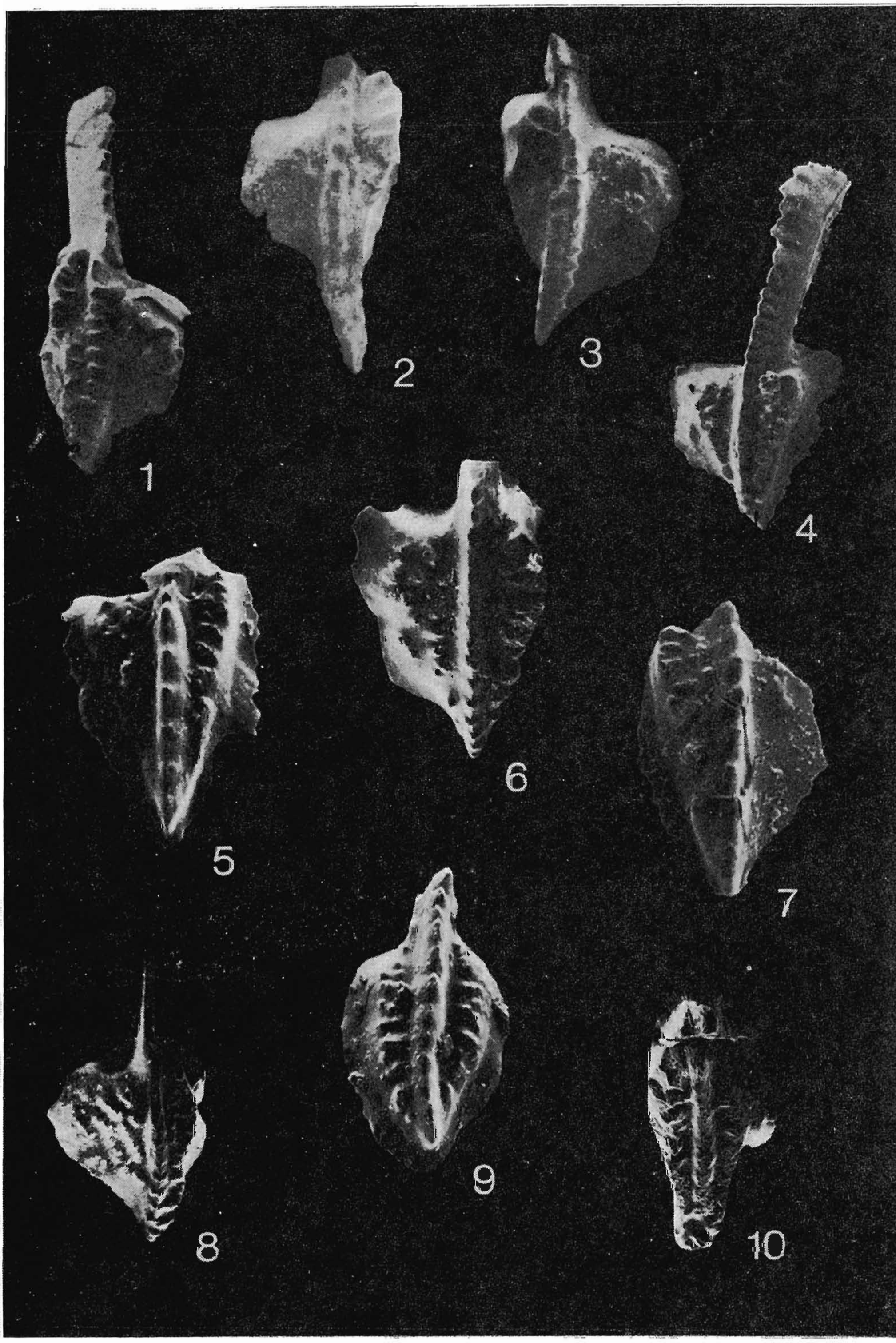
1-3 — *Gnathodus semiglaber* (BISCHOFF, 1957); *1* from Sosnowiec (depth 1781 m), ×24; *2* from Sosnowiec (depth 1790.5 m), ×40; *3* from Sosnowiec (depth 1784 m), ×37

4-8 — *Gnathodus praebilineatus* sp. n.; *4* from BE-75 (depth 448.5 m), holotype, ×60; *5* from BE-75 (depth 467.6 m), ×89; *6* from BE-75 (depth 456 m), ×69; *7* from BO-150 (depth 166.5 m). ×54; *8* from BO-162 (depth 356.8 m), ×52

9 — *Gnathodus mermaidus* AUSTIN & HUSRI, 1974; BE-75 (depth 448.5 m), ×75

10 — *Gnathodus girtyi* cf. *intermedius* GLOBENSKY, 1967; BO-162 (depth 334 m), ×51

All upper views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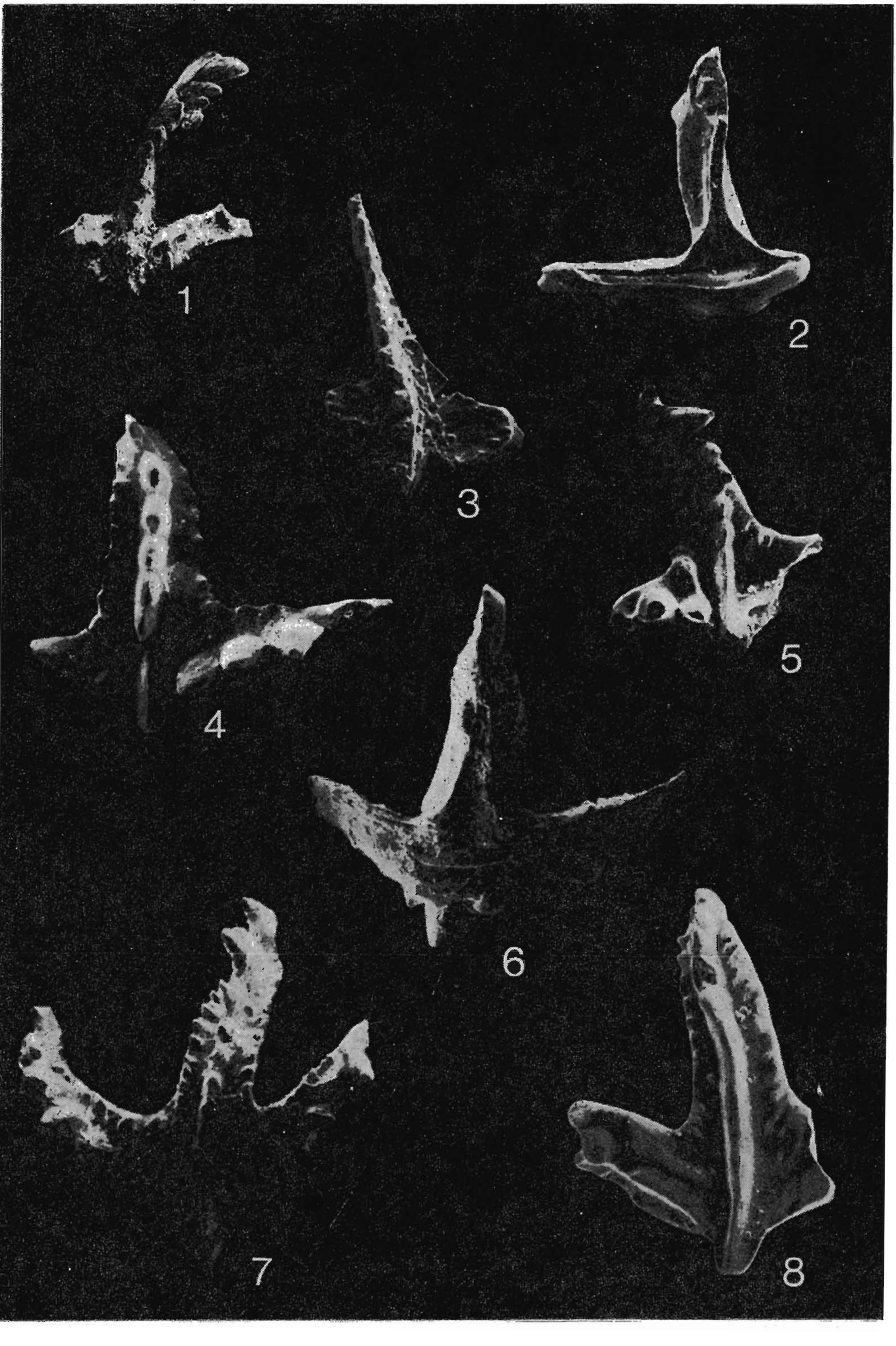
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& PLINT-GEBERL (1982). These zonations, usually reflecting only the local ranges of taxa did not prove, however, to be of a global use. In the last years, therefore, the necessity of a standard conodont zonation for the Lower Carboniferous has become evident. On the other hand, at the same time the discontinuities in the "orthostratigraphical" ammonoid zonation of SCHMIDT (1925) have been recognized: MATTHEWS (1970a, b) and PAPROTH (1970) showed that there are two significant intervals in which no ammonoid zones are established. The first interval falls between the *Gattendorfia-* and *Pericyclus*-Stufe, whereas the second one occurs within the Viséan, comprising approximately its middle portion (Text-fig. 4). Subsequently to this recognition, SANDBERG & *al.* (1978) introduced a preliminary standard zonation based on the stratigraphic ranges of particular species of *Siphonodella*, and they subdivided the Lower and Middle Tournaisian (Kinderhookian) into six zones, the precision of which rivals the standard Upper Devonian conodont zonation. In 1980, LANE, SANDBERG & ZIEGLER distinguising the three succeeding zones (*typicus*, *anchoralis-latus*, and *texanus*) expanded the preliminary standard zonation on the post-*Siphonodella*/pre-*bilineatus* interval. This zonal scheme has been constructed to provide the potential basis for a worldwide correlation. To this end, the major changes in the Lower Carboniferous conodont sequence marked by the first appearance of the most important species of *Siphonodella*, *Gnathodus*, and *Scaliognathus* were used.

In the course of nature, the global application of this zonation is however limited due to ecological reasons. The worldwide distribution as the majority of the Lower Carboniferous conodonts yield, some of them show very restricted environmental tolerances. The genera *Siphonodella* and *Scaliognathus*, considered to be deep-water (AUSTIN & BARNES 1973; AUSTIN 1976), delimit the application of the standard zonal scheme to the shelf-slope and off-shelf environment (*cf.* SANDBERG & GUTSCHICK 1979; LANE & ZIEGLER 1983). For the shallow-water shelf area with conodont fauna dominated (*see* AUSTIN 1976; MERILL & MARTIN 1976; von BITTER 1976) by asymmetric forms as *Cavusgnathus*, *Taphrognathus*, *Clydagnathus*, *Patrognathus*, and *Mestognathus*, an alternative zonal scheme is necessary. To correlate these independent zonations the genus *Gnathodus* would have been very useful, because sometimes it occurs with deep-water, and sometimes with shallow-water asymmetric conodonts (*see* AUSTIN 1976; SANDBERG & GUTSCHICK 1979).

PLATE 8

1 — *Dollymae bouckaerti* GROESSENS, 1971; Sosnowiec (depth 1859 m), ×32

2, 4-5 — *Scaliognathus praeanchoralis* LANE, SANDBERG & ZIEGLER, 1980; *2* from Sosnowiec (depth 1845.5 m), lower view, ×91; *4* from Sosnowiec (depth 1842.5 m), ×79; *5* from Sosnowiec (depth 1844.5 m), ×56

3 — *Dollymae* sp.; Sosnowiec (depth 1819 m), ×75

6-8 — *Scaliognathus anchoralis europensis* LANE & ZIEGLER, 1983; *6* from Sosnowiec (depth 1815.7 m), lower view, ×52; *7* from Sosnowiec (depth 1815.7 m), ×48; *8* from WB-64 (depth 165 m), ×53

All upper views, except Figs 2 and 6

Based upon conodonts, the previous biostratigraphic studies of the Lower Carboniferous in Poland correlated the investigated sections using different zonations established in Germany, Belgium and/or England and no separate scheme has been introduced. The conodont subdivision proposed by RHODES, AUSTIN & DRUCE (1969) for the British Avonian (uppermost Famennian, Tournaisian and Viséan) was adopted by SKOMPSKI & SOBOŃ-PODGÓRSKA (1980), as well as by GROMCZAKIEWICZ-ŁOMNICKA (1974) and BEŁKA (1982) to correlate the uppermost Viséan deposits in the Lublin Coal Basin and in the Cracow Upland, respectively. For the Lower Viséan conodont fauna of the Cracow Upland (GROMCZAKIEWICZ-ŁOMNICKA 1979; MATYJA & NARKIEWICZ 1979) the most useful scheme appeared that of AUSTIN (1973) with its modification made by GROESSENS, CONIL & LEES (1976). SZULCZEWSKI (1973), however, applied VOGES' (1960) zonation to subdivide the conodont sequence present within the neptunian dykes developed in the Upper Devonian bioherm of the Holy Cross Mts.

To correlate the Lower Carboniferous deposits from the Moravia-Silesia Basin, the preliminary standard conodont zonation (SANDBERG & *al.* 1978; LANE, SANDBERG & ZIEGLER 1980) is adopted here. Some modifications of this scheme are proposed to offer facilities for its usage. Moreover, two successive conodont zones are introduced to extend the scheme upwardly, until the first occurrence of *Paragnathodus nodosus* within the Upper Viséan. These are the *austini* Zone and *bilineatus* Zone, the first of which is a new, consecutive-range zone, while the latter was established by VOGES (1960) and subsequently often recognized in many Lower Carboniferous sections.

CRENULATA PARTIAL-RANGE ZONE

SYNONYMS: *Siphonodella crenulata* Zone; VOGES (1960), lower Subzone only.
Untere *Siphonodella crenulata* Zone; MEISCHNER (1970).
Lower *crenulata*-Zone; SANDBERG & *al.* (1978).
Lower *Siphonodella crenulata* Zone; SANDBERG (1979).
Lower *Siphonodella crenulata* Zone; SANDBERG (*in*: GUTSCHICK & *al.* 1980).

DEFINITION: Interval from the first occurrence of the zonal marker *Siphonodella crenulata* to the first occurrence of *Gnathodus delicatus*.

PLATE 9

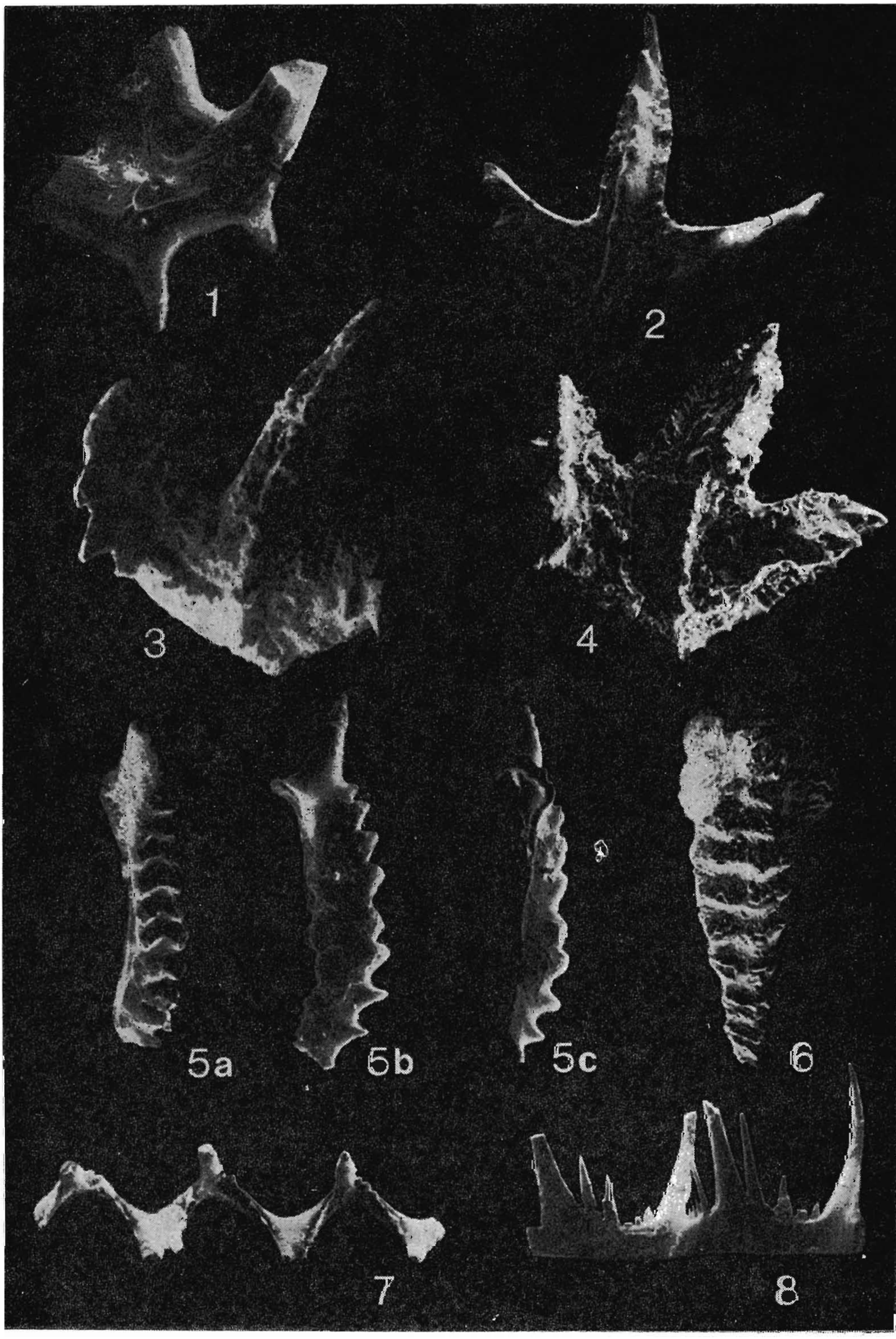
1-2 — *Scaliognathus anchoralis europensis* LANE & ZIEGLER, 1983; *1* from Sosnowiec (depth 1842.5 m), lower view, specimen transitional to *Sc. a. anchoralis*, ×43; *2* from Sosnowiec (depth 1814.5 m), juvenile specimen, upper view, ×115

3-4 — *Scaliognathus anchoralis anchoralis* LANE & ZIEGLER, 1983; *3* from Sosnowiec (depth 1819 m), upper view, ×42; *4* from Sosnowiec (depth 1820.5 m), upper view, ×54

5 — *Eotaphrus burlingtonensis* PIERCE & LANGENHEIM, 1974; Sosnowiec (depth 1819 m), ×44, 5a — oblique upper view; 5b — lateral view; 5c — oblique lower view

6 — *Eotaphrus*? sp. *V* of LANE, SANDBERG & ZIEGLER, 1980; Sosnowiec (depth 1859 m), upper view, ×43

7-8 — *Hindeodella segaformis* STAUFFER, 1938; *7* from Sosnowiec (depth 1814.5 m), upper view, ×58; *8* from Sosnowiec (depth 1819 m), lateral view, ×68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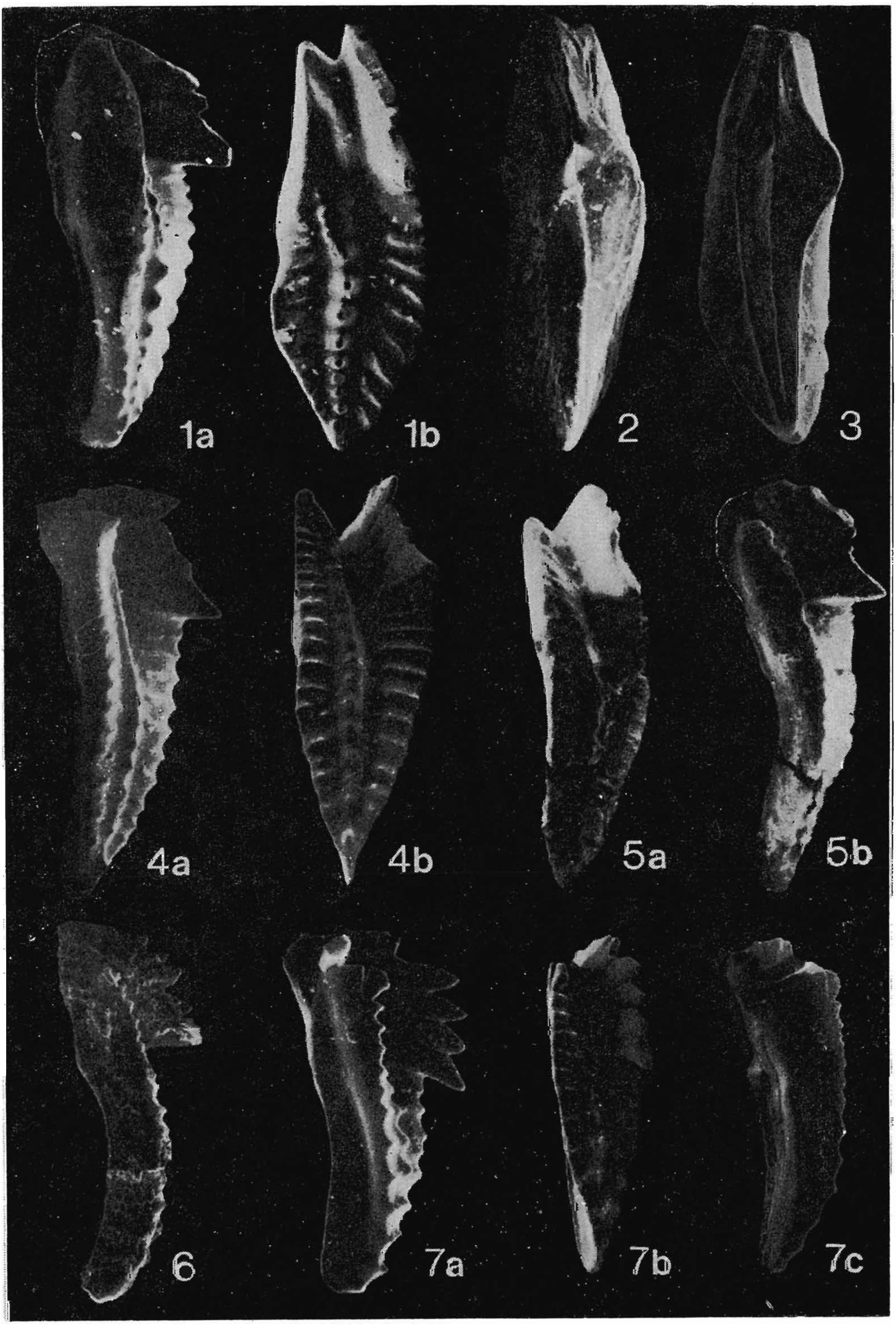
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ASSOCIATED FAUNA: The most significant taxa in this zone are siphonodellids: *S. crenulata* (both morphotypes), *S. duplicata* Morphotype *2*, *S. cooperi* Morphotype *2*, *S. lobata*, *S. quadruplicata*, and *S. obsoleta*. The non-platform elements as *Elictognathus peculiaris*, *Dinodus fragosus*, *D. leptus* and *D. wilsoni* that presumably belong together with siphonodellid platform elements to the same multielement apparatus, are relatively rare. Additional important forms are: *Bispathodus aculeatus aculeatus* (terminating within this zone), *B. stabilis*, *Polygnathus communis communis*, *P. inornatus*, *P. purus purus*, *P. purus subplanus*, *P. symmetricus*, and *P. triangulus*.

AGE: The *crenulata* Zone was established by VOGES (1960) who considered it as an equivalent to the lower part of the *Pericyclus*-Stufe (*Pea*). Later on, however, the investigations of goniatites both from the Culm and the Carboniferous Limestone facies showed that any ammonoid fauna indicative of the *Pea* Zone does not appear before the uppermost Tournaisian (*Tn3c*). Thus, the species *Siphonodella crenulata*, which appears at the base of *Tn2a*, is much older than the *Pea* Zone.

The *crenulata* Zone introduced herein corresponds to the lower part of the Middle Tournaisian (*Tn2*) and it is correlated to the interval occurring in the ammonoid succession between the *Gaβ* Zone and the *Pea* Zone (Text-fig. 4).

LOCALITIES: Boreholes Sosnowiec *IG-1, BO-159, WB-64,* and *BK-318.*

REMARKS: VOGES (1960) divided the *crenulata* Zone into two subzones, the lower and the upper with *Gnathodus semiglaber* (incorrectly identified by VOGES *G. delicatus*). Following this concept, SANDBERG & *al.* (1978) used in their *Siphonodella*-zonation *G. delicatus*, the species from another evolving group, in order to define the boundary between the Lower *crenulata* and the *isosticha*-Upper *crenulata* Zones. This was because that the genus *Siphonodella* before its extinction did not provide any new species. The first representatives of *Gnathodus* as *G. delicatus* and *G. punctatus* are in fact the only useful taxa which afford possibilities for a subdivision of the interval corresponding to the *crenulata* Zone *sensu* VOGES (1960).

The former *crenulata* Zone is subdivided herein into two separate Zones, *crenulata* and *delicatus*, which are equivalent to the Lower *crenulata* and the *isosticha*-Upper *crenulata* Zones, respectively. This treatment does not change the framework of the preliminary standard conodont zonation proposed for the Lower Carboniferous by SANDBERG & *al.* (1978), but it uniforms the general approach to definition of zones throughout the zonation and it also allows to simplify the zonal names.

DELICATUS CONSECUTIVE-RANGE ZONE

SYNONYMS: *Siphonodella crenulata* Zone; VOGES (1960), upper Subzone only.
Obere *Siphonodella cernulata* Zone; MEISCHNER (1970).
isosticha-Upper *crenulata* Zone; SANDBERG & *al.* (1978).
Siphonodella isosticha — Upper *Siphonodella crenulata*-Zone; SANDBERG (1979).
Siphonodella isosticha — Upper *Siphonodella crenulata* — Zone; SANDBERG (*In*: GUTSCHICK & al. 1980).

DEFINITION: Interval from the first occurrence of the zonal marker *Gnathodus delicatus* to the first occurrence of *Gnathodus cuneiformis.*

PLATE 10

1-3, 5-6 — *Mestognathus groessensi* BEŁKA, 1983; *1* from WB-64 (depth 125 m), rephotograph of holotype (BEŁKA 1983, Pl. 1, Fig. 1), ×53; **1a** — lateral view; **1b** — upper view; *2* from WB-64 (depth 147.5 m), lower view, ×60; *3* from WB-64 (depth 165 m), lower view of specimen with asymmetrical, *Clydagnathus*-like basal cavity, ×55; *5* from Sosnowiec (depth 1815.7 m), ×35, **5a** — upper view; **5b** — inner lateral view; *6* from Sosnowiec (depth 1819 m), inner lateral view, ×60

4, 7 — *Mestognathus beckmanni* BISCHOFF, 1957; *4* from Sosnowiec (depth 1782.5 m), ×54, **4a** — inner lateral view; **4b** — upper view; *7* from Sosnowiec (depth 1782.5 m), **7a** — inner lateral view, ×86; **7b** — upper view, ×71; **7c** — oblique lower view, ×66

ASSOCIATED FAUNA: The last siphonodellids, *S. cooperi* Morphotype *2*, *S. crenulata*, *S. obsoleta*, *S. isosticha→obsoleta* and *S. isosticha* extinct within the zone. The genus *Gnathodus* is represented by three species, *G. delicatus*, *G. punctatus*, and *G. typicus* Morphotype *1*. Other taxa that first appear within this zone are *Mestognathus groessensi*, *Eotaphrus bultyncki* and *Pseudopolygnathus multistriatus* Morphotype *1*. These occur along with *Polygnathus communis communis*, *P. communis carinus*, *P. flabellus*, *P. inornatus*, *Bispathodus stabilis*, *Clydagnathus unicornis*, and *Protognathodus praedelicatus*.

AGE: The *delicatus* Zone along with the *crenulata* Zone both are correlated with the interval below the *Pea* Zone, in which no ammonoid zones are recognized (*cf.* Text-fig. 4). This corresponds approximately to the Middle Tournaisian (*Tn2*) and the lowermost part of the Upper Tournaisian (*Tn3a*).

LOCALITIES: Boreholes Sosnowiec *IG-1*, *BO-150*, and *WB-64*.

REMARKS: The lower limit of the zone was discussed in detail by SANDBERG & *al.* (1978) and also briefly under the characteristics of the preceding unit. The *isosticha*-Upper *crenulata* Zone, which is revised here to establish the *delicatus* Zone, was the only one concurrent-range zone within the preliminary standard Lower Carboniferous conodont zonation (SANDBERG & *al.* 1978; LANE, SANDBERG & ZIEGLER 1980). Its upper limit, defined by extinction of *Siphonodella isosticha*, was not in the same time the lower limit of the next zone. In practice, such deviation could cause a spreading of zones to produce an unzoned interval between *isosticha*-Upper *crenulata* and *typicus* Zones. For this reason the upper limit of the *isosticha*-Upper *crenulata* Zone was revised as well as the name of this unit was changed. The concept of the present paper was to define the base of zones on the first appearance of the zonal name-bearer.

CUNEIFORMIS CONSECUTIVE-RANGE ZONE

SYNONYMS: Zone à *Polygnathus communis carina*; GROESSENS (1974).
Gnathodus typicus — Zone; SANDBERG (1979).
typicus — Zone; LANE, SANDBERG & ZIEGLER (1980).

DEFINITION: Interval from the first occurrence of the zonal marker *Gnathodus cuneiformis* to the first occurrence of *Scaliognathus anchoralis europensis* or *Doliognathus latus*, or both.

ASSOCIATED FAUNA: Along with the index species, *Gnathodus cuneiformis*, other important taxa as *Protognathodus cordiformis*, *Pseudopolygnathus oxypageus*, *Ps. pinnatus*, *Dollymae bouckaerti*, and *Scaliognathus praeanchoralis* enter within this zone. Other conodonts present in the *cunei-*

PLATE 11

1 — *Cavusgnathus convexus* REXROAD, 1957; BO-145a (depth 150.5 m), **1a** — upper view, ×75; **1b** — inner lateral view, ×82

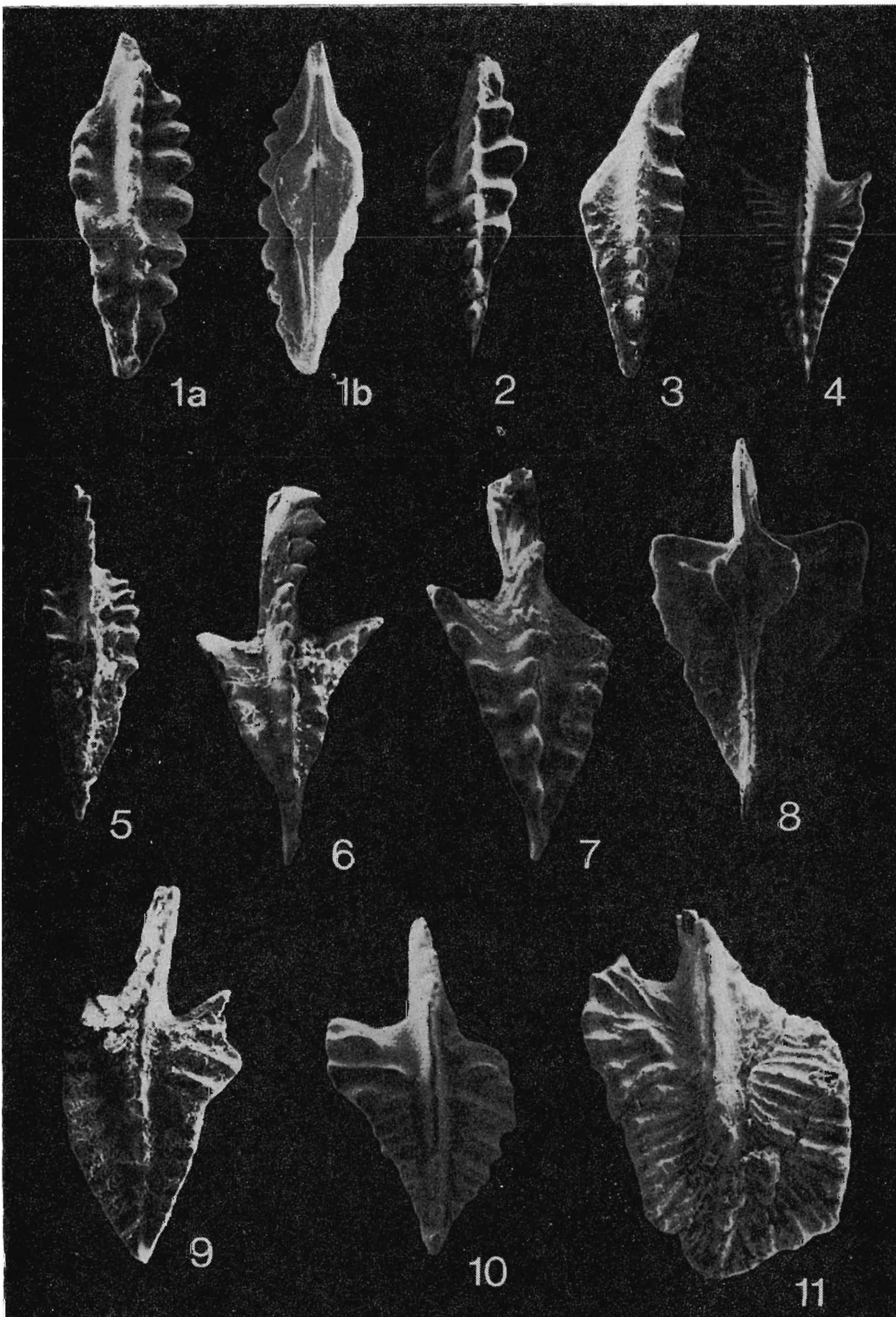
2 — *Cloghergnathus globenskii* AUSTIN, 1975; BO-145a (depth 177 m), **2a** — upper view, ×44; **2b** — inner lateral view, ×47

3 — *Clydagnathus unicornis* RHODES, AUSTIN & DRUCE, 1969; BO-150 (depth 480 m), inner view, ×69

4 — *Clydagnathus* sp.; BO-149 (depth 216 m), ×66, **4a** — inner lateral view; **4b** — upper view

5-6 — *Paragnathodus cracoviensis* sp. n.; *5* from BO-145a (depth 173 m), **5a** — upper view, ×79; **5b** — fragment of expanded blade, ×380; *6* from Sosnowiec (depth 1779 m), holotype, **6a** — upper view, ×54; **6b** × lateral view, —66

7-8 — *Paragnathodus commutatus* (BRANSON & MEHL, 1941); *7* from BO-162 (depth 354.8 m), ×66., **7a** — upper view; **7b** — oblique lateral view; *8* from BO-162 (depth 353.3 m), lateral view, ×55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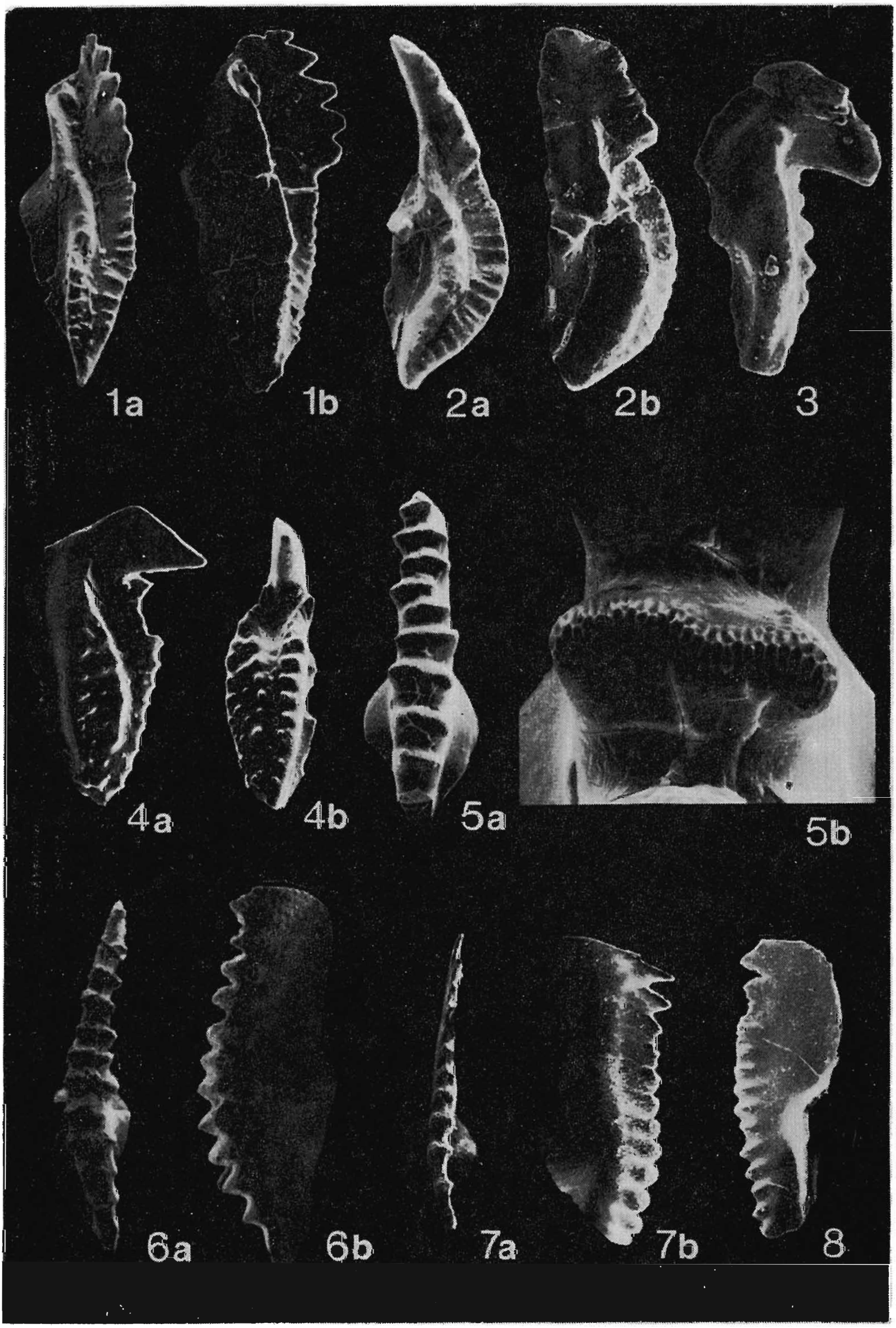
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formis Zone include: *G. punctatus*, which do not range as high as the top of the zone, *G. delicatus*, *Pseudopolygnathus multistriatus* Morphotype *1*, *Polygnathus communis communis*, *P. flabellus*, *P. inornatus*, *P. longiposticus*, *Mestognathus groessensi*, and *Bispathodus stabilis*.

AGE: In relation to the ammonoid sequence, the *cuneiformis* Zone corresponds almost to the whole *Pea* Zone, which equates well with the lower- and middle-third of the Upper Tournaisian.

LOCALITIES: Boreholes Sosnowiec *IG-1*, *BO-150*, and *WB-64*.

REMARKS: The *cuneiformis* Zone replaces the *typicus* Zone establish by LANE, SANDBERG & ZIEGLER (1980), the base of which was defined by the first appearance of *Gnathodus typicus* Morphotype *2*. Owing to the poorly illustrated holotype of *Gnathodus typicus* (COOPER 1939) there previously were different interpretations of the concept of this species, and some forms of *Gnathodus cuneiformis*, *G. semiglaber* and *G. pseudosemiglaber* were identified as *G. typicus*.

In the Lower Viséan of the Pyrenees (BOERSMA 1973; MARKS & WENSINK 1970; BUCHROITHNER 1979) and Styria (EBNER 1977) immature specimens of *G. pseudosemiglaber* and/or *G. austini* have been described as *G. typicus*, on which a separate zone has been based there. As a consequence, in some previous zonations of the Lower Carboniferous, the *typicus* Zone occurs below the well-defined *anchoralis* Zone, while in other cases it is placed above this interval, that is higher than the factual range of *Gnathodus typicus*.

The species *Gnathodus typicus* has recently been revised by LANE, SANDBERG & ZIEGLER (1980). The examination of COOPER's (1939) fauna as well as that one from several North American and European occurrences let these authors to distinguish two biostratigraphically significant morphotypes of *G. typicus*. This species, relatively abundant in the Mississippian rocks of North America, is extremely rare in the European sections. Only two specimens of Morphotype *1* and eighteen of Morphotype *2* have been found in the investigated sections from the Moravia-Silesia Basin, but first of all within the *anchoralis* Zone.

Thus, for these reasons, it seems justified to replace the *typicus* Zone by the *cuneiformis* Zone. This is also because the ranges of both taxa, *G. typicus* Morphotype *2* and *G. cuneiformis* are almost completely overlapped, and the new zonal marker both in Europe and in North America is relatively frequent. As presently known, *G. cuneiformis* has its first appearance just after that of *G. typicus* Morphotype *2* (LANE, SANDBERG & ZIEGLER 1980).

Recently, MORY & CRANE (1982) have reported the ealiest representatives of the species of *Gnathodus* from the Tournaisian sections of eastern Australia. According to these authors, *G. cuneiformis* has its first occurrence near the base of *crenulata* Zone, *i. e.* much earlier than in Europe and North America. The presented details of the distribution of the species (MORY & CRANE 1982, Tables 3, 4 and 6), however, do not provide any clear evidences for such conclusion.

PLATE 12

1-3 — *Pseudopolygnathus multistriatus* MEHL & THOMAS, 1947, Morphotype *1*; *1* from WB-64 (depth 108.5 m), juvenile specimen, **1a** — upper view, ×67; **1b** — lower view, ×62; *2* from Sosnowiec (depth 1881.5 m), juvenile specimen, ×65; *3* from WB-64 (depth 112 m), juvenile specimen, ×56

4-7 — *Pseudopolygnathus oxypageus* LANE, SANDBERG & ZIEGLER, 1980; 4 from Sosnowiec (depth 1847 m), Morphotype *2*, ×31; *5* from Sosnowiec (depth 1820.5 m), Morphotype *3*, ×55; *6* from Sosnowiec (depth 1845.5 m), Morphotype *1*, ×57; *7* from Sosnowiec (depth 1819 m), Morphotype *2*, ×60

8-10 — *Pseudopolygnathus pinnatus* VOGES, 1959; *8* from Sosnowiec (depth 1819 m), lower view, ×66; *9* from Sosnowiec (depth 1820.5 m), ×60; *10* from BO-150 (depth 397 m), ×35

11 — *Polygnathus* sp. *A* sensu GEDIK, 1974; BO-150 (depth 525 m), ×39

All upper views, except as noted

ANCHORALIS INTERVAL-RANGE ZONE

SYNONYMS: *anchoralis*-Subzone; BISCHOFF (1957).
anchoralis-Zone; VOGES (1960).
anchoralis-Zone; WIRTH (1967).
Anchoralis-Zone; ADRICHEM BOOGAERT (1967).
Scaliognathus anchoralis-Zone; MARKS & WENSINK (1960).
Scaliognathus anchoralis-Zone; MEISCHNER (1970).
Scaliognathus anchoralis-Zone; BOERSMA (1973).
Zone à *Scaliognathus anchoralis*; BOYER & *al.* (1974).
Zone à *Scaliognathus anchoralis*; GROESSENS (1974).
Scaliognathus anchoralis Zone; JENKINS (1974).
Scaliognathus anchoralis Zone; EBNER (1977).
Zone à *Scaliognathus anchoralis*; PERRET (1977).
Scaliognathus anchoralis-Zone; BUCHROITHNER (1979).
Doliognathus latus Zone; SANDBERG (1979).
anchoralis-latus-Zone; LANE, SANDBERG & ZIEGLER (1980).
Anchoralis Zone; HIGGINS & WAGNER-GENTIS (1982).

DEFINITION: Interval from the first occurrence of *Scaliognathus anchoralis europensis* or *Doliognathus latus*, or both through to the first occurrence of *Gnathodus texanus*.

ASSOCIATED FAUNA: The life-span of *Sc. a. europensis* is almost identical with the range of the zone. The same is also the stratigraphic range of *Hindeodella segaformis*. These both elements, most likely, constitute part of the multielement apparatus (*cf.* CHAUFF 1981), the composition of which is hitherto unknown. Other important taxa that terminate within this zone are: *Doliognathus latus*, *Eotaphrus burlingtonensis*, *Bispathodus stabilis*, *Polygnathus bischoffi*, *P. flabellus*, *P. inornatus*, *Pseudopolygnathus multistriatus* Morphotype *1*, *Ps. oxypageus*, *Ps. pinnatus*, *Protognathodus cordiformis*, *Gnathodus cuneiformis*, *G. delicatus*, *G, typicus* Morphotype *2*, and *Mestognathus groessensi*. The other species of *Gnathodus* that have their first appearance in the *anchoralis* Zone and range higher are *G. homopunctatus*, *G. pseudosemiglaber*, *G. semiglaber*, and *G. symmutatus*.

AGE: The *anchoralis* Zone was, in the past, very frequently identified in many Lower Carboniferous sections throughout the world. However, it is still difficult to state precisely its stratigraphic position in relation to the ammonoid sequence. This is because that the hitherto existing correlations (VOGES 1960; MEISCHNER 1970) were in part based on mixed conodont faunas. According to VOGES, the *anchoralis* Zone corresponds to the middle part of the *Pericyclus*-Stufe (*Peβ/γ*). In Belgium, at the Tournaisian/Viséan boundary stratotype in Dinant, *Scaliognathus anchoralis* (presumably only *Sc. a. europensis* — *cf.* LANE & ZIEGLER 1983) occurs in the uppermost Tournaisian beds (*Tn3c*), but it does not extend above the boundary between Tournaisian and Viséan (GROESSENS 1974). Thus, most frequently, there was commonly assumed the coincidence of the

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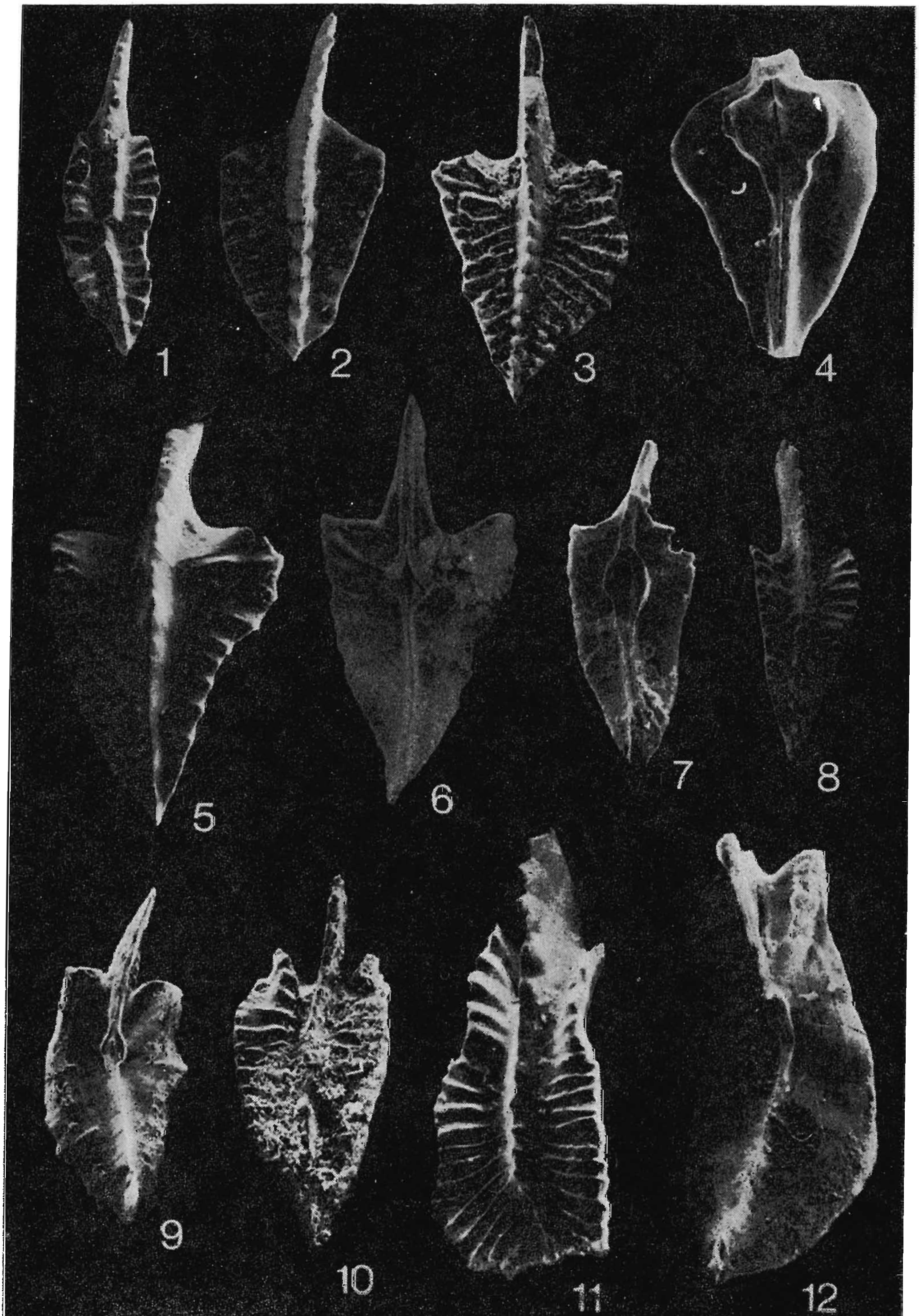
PLATE 13

1 — *Polygnathus symmetricus* E. R. BRANSON, 1934; BO-150 (depth 554.5 m), ×27
2-4 — *Polygnathus triangulus* (VOGES, 1959); *2* from BO-150 (depth 563.2 m), ×66; *3* from BK-318 (depth 657 m), ×44; *4* from BO-150 (depth 564.3 m), juvenile specimen, lower view, ×76
5-6 — *Pseudopolygnathus pinnatus* VOGES, 1959; *5* from Sosnowiec (depth 1814.5 m), ×65; *6* from Sosnowiec (depth 1819 m), lower view, ×38
7-12 — *Polygnathus inornatus* E.R. BRANSON, 1934; *7* from Sosnowiec (depth 1815.7 m), juvenile specimen, lower view, ×41; *8* from Sosnowiec (depth 1813 m), juvenile specimen, ×43; *9* from Sosnowiec (depth 1820.5 m), lower view, ×25; *10* from Sosnowiec (depth 1820.5 m), ×52; *11* from Sosnowiec (depth 1912 m), ×42; *12* from Sosnowiec (depth 1912 m), lower view, ×45
All upper views, except as noted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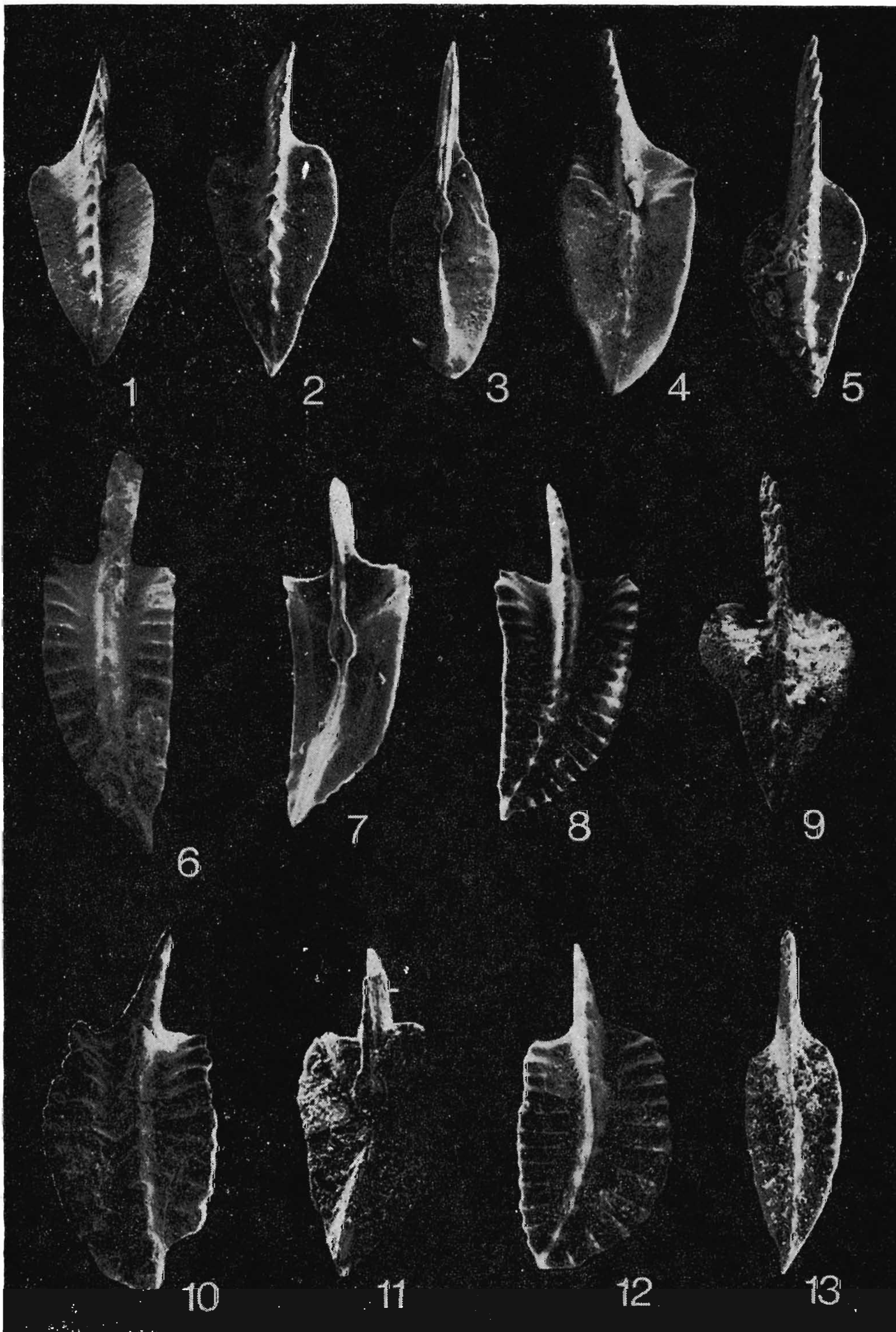
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upper limit of the *anchoralis* Zone with the Tournaisian/Viséan boundary (AUSTIN 1973; JENKINS 1974; EBNER 1977; CONIL, GROESSENS & PIRLET 1976; PERRET 1977).

LOCALITIES: Boreholes Sosnowiec *IG-1, BO-150, BO-145a,* and *BO-162.*

REMARKS: LANE & ZIEGLER (1983) in their *Scaliognathus* monograph restricted considerably the range of *Sc. a. europensis* because in many North American localities it became extinct much below the upper boundary of the *anchoralis* Zone. As a consequence, they suggested to place the Tournaisian/Viséan boundary within the *anchoralis* Zone. They correlate the extinction of *Scaliognathus anchoralis* in the boundary stratotype section in the Dinant region to that of *Sc. a. europensis* in North America, where the latter taxon ranges upward approximately as high as the middle of the *anchoralis* Zone. In Dinant, however, the appearance of *Gnathodus texanus,* a zonal marker of the next, younger *texanus* Zone, has not yet been documented, and just above the Tournaisian/Viséan boundary there appears the species *Mestognathus beckmanni* that *vice versa* is unknown in the central and western United States.

To compare with the conodont fauna obtained during the present work, the correlation suggested by LANE & ZIEGLER (1983) does not appear valid. In southern Poland, *Mestognathus beckmanni* and *Scaliognathus anchoralis europensis* occur in the same order (Text-fig. 3) as in Belgium (except the section at Yvoir where these both taxa occur together in one sample — *cf.* GROESSENS 1974), and *Gnathodus texanus* has its first appearance almost simultaneously, only a little higher than *M. beckmanni.* There is therefore indication that the Tournaisian/Viséan boundary have to be placed just below the top of the *anchoralis* Zone.

The *anchoralis* Zone falls in time when the Carboniferous conodonts underwent the most rapid and eruptive evolution. In that time, the conodont fauna was so highly diversified as never before and later, and usually it is abundantly represented in the fossil record. The massive radiation which produced many new species and genera during time of the *cuneiformis* Zone, has been followed by a widespread extinction within the *anchoralis* Zone. All short-ranging Tournaisian conodont genera (e. g. *Staurognathus, Doliognathus, Scaliognathus, Bactrognathus,* and *Dollymae*) become extinct. Moreover, other genera important in the Devonian and Tournaisian owing to their high biostratigraphical potential, as *Polygnathus, Pseudopolygnathus, Protognathodus* and *Bispathodus,* almost completely disappear. Only gnathodids are created to dominate in the younger Viséan strata, except of the shallow-water shelf settings, where new asymmetric forms like *Cavusgnathus* and/or *Cloghergnathus* start to develop.

TEXANUS CONSECUTIVE-RANGE ZONE

DEFINITION: Interval from the first occurrence of the zonal marker *Gnathodus texanus* to the first occurrence of *Gnathodus austini.*

PLATE 14

1-3 — *Polygnathus communis communis* BRANSON & MEHL, 1934; from Sosnowiec (depth 1842.5 m), *1* — ×43; *2* — ×62; *3* — lower view, ×55

4 — *Polygnathus communis carinus* HASS, 1959; Sosnowiec (depth 1881.5 m), ×44

5, 9 — *Polygnathus purus purus* VOGES, 1959; *5* from BO-150 (depth 564.3 m), ×92; *9* from Sosnowiec (depth 1955.8 m), ×91

6-8 — *Polygnathus bischoffi* RHODES, AUSTIN & DRUCE, 1969; *6* from Sosnowiec (depth 1819 m), ×58; 7 from BO-150 (depth 411 m), ×52; *8* from BO-150 (depth 411 m), ×54

10-12 — *Polygnathus flabellus* (BRANSON & MEHL, 1938); *10* from Sosnowiec (depth 1909.6 m), ×64; *11* from Sosnowiec (depth 1815.7 m), lower view, ×37; *12* from BO-150 (depth 419 m), ×65

13 — *Polygnathus mehli* THOMPSON, 1967; BK-318 (depth 655 m), ×56

All upper views, except as noted

ASSOCIATED FAUNA: Conodont fauna present in this zone is undiversified and it is dominated by gnathodids. Except the zonal name bearer, *Gnathodus texanus*, they are *G. homopunctatus*, *G. mermaidus*, *G. pseudosemiglaber*, *G. semiglaber*, *G. symmutatus*, and two species of the genus *Paragnathodus*, viz. *P. cracoviensis* sp. n. and *P. commutatus*. Moreover, in the shelf area there occur shallow-water asymmetric forms as very important taxon *Mestognathus beckmanni*, and also but sporadically *Cavusgnathus convexus* and *Cloghergnathus globenskii*. The longest-ranging taxon of the Lower Carboniferous, *Polygnathus communis communis* terminates within the zone.

AGE: In relation to the ammonoid sequence, the *texanus* Zone corresponds to the middle and upper parts of the *Pericyclus*-Stufe, *i. e.* to the *Pey* Zone and the interval above it, in which no ammonoid zones are recognized (Text-fig. 4). This allows to correlate it with the Lower Viséan (*V1*), since the *texanus* Zone in part equates with the *beckmanni* Zone distinguished in Belgium by GROESSENS (1974).

LOCALITIES: Boreholes Sosnowiec *IG-1, BO-150, BO-162, BO-145a,* and *BO-149.*

REMARKS: The *texanus* Zone was established by LANE, SANDBERG & ZIEGLER (1980) to constitute a part of their preliminary standard Lower Carboniferous conodont zonation. During the present work, the upper limit of that unit has been revised, the more so as there was a divergence between the description of the *texanus* Zone (LANE, SANDBERG & ZIEGLER 1980; p. 120) and the close-by scheme presented by these authors (p. 118).

As a consequence of the revision proposed herein, the former *texanus* Zone is divided onto two separate Zones, *texanus* and *austini.*

AUSTINI CONSECUTIVE-RANGE *ZONE*

DEFINITION: Interval from the first occurrence of the zonal marker *Gnathodus austini* to the first occurrence of *Gnathodus bilineatus bilineatus.*

ASSOCIATED FAUNA: This zone is also characterized by very scanty fauna similar to that of the *texanus* Zone. the zonal marker, *G. austini* sp. n. is associated by *Paragnathodus commutatus*, *P. cracoviensis* sp. n., *G. texanus*, *G. mermaidus*, *G. homopunctatus*, *G. symmutatus*, and *G. praebilineatus* sp. n. that first appears at the base of the zone being an additional aid to recognition of the *austini* Zone. The species *Mestognathus beckmanni* occurs throughout the zone but erratically and in small numbers.

PLATE 15

1 — „*Spathognathodus*" sp. *A*; BO-150 (depth 411 m), **1a** — upper view, ×64; **1b** — lateral view, ×66

2 — „*Spathognathodus*" *scitulus* HINDE, 1900; BO-150 (depth 500 m), lateral view, ×83

3 — „*Spathognathodus*" *praelongus* COOPER, 1943; WB-64 (depth 161 m), lateral view, ×66

4 — *Bispathodus stabilis* (BRANSON & MEHL, 1934); Sosnowiec (depth 1845.5 m), lateral view, ×58

5 — *Eotaphrus* cf. *bultycki* (GROESSENS, 1971); WB-64 (depth 125 m), **5a** — upper view, ×70; **5b** — oblique lateral view, ×56

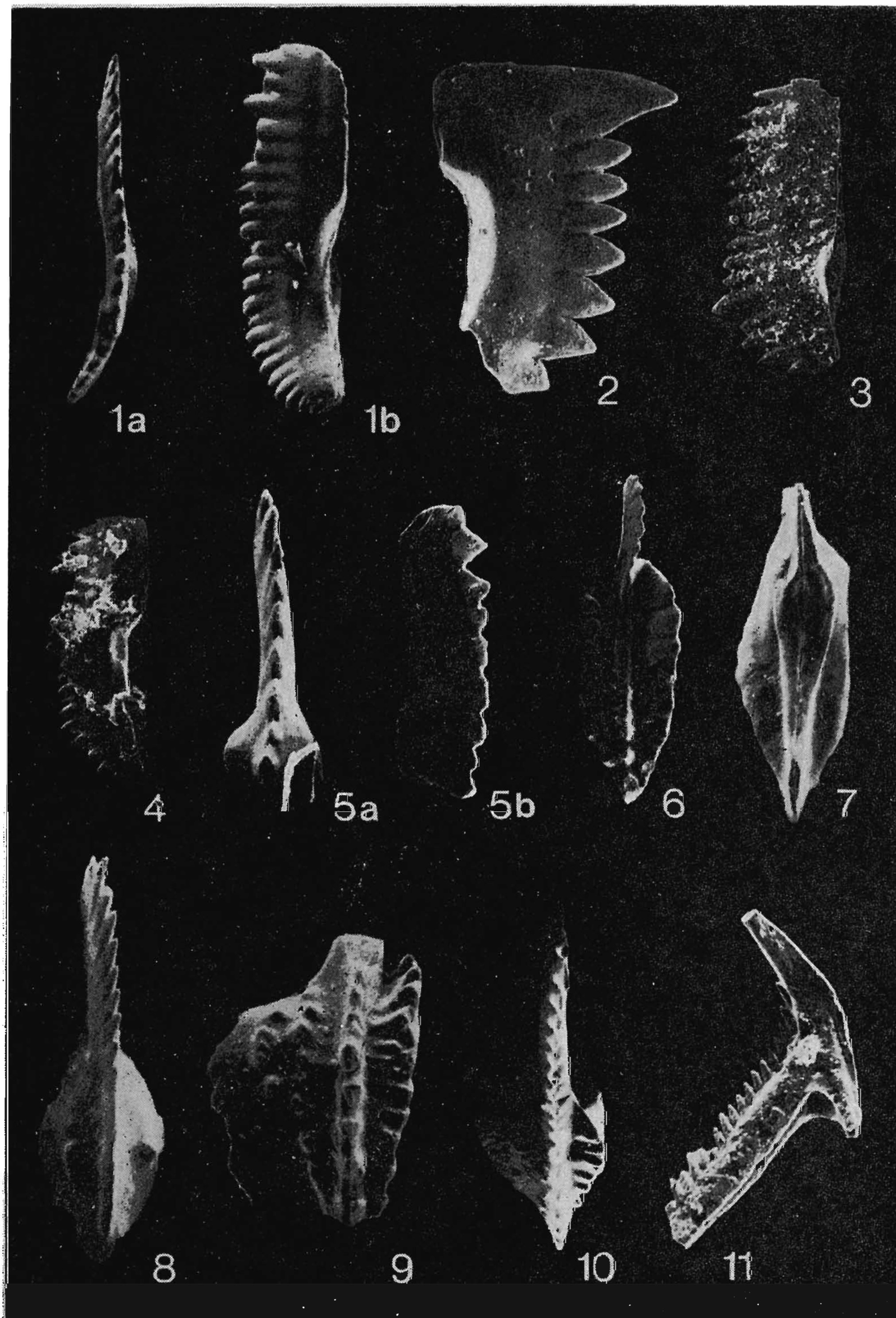
6—7 — *Polygnathus longiposticus* BRANSON & MEHL, 1934; from BO-150 (depth 429 m), 6 — upper view, ×75; 7 — lower view, ×62

8 — *Gnathodus symmutatus→homopunctatus*; BO-162 (depth 353.3 m), juvenile specimen, upper view, ×102

9 — *Gnathodus cuneiformis* MEHL & THOMAS, 1947; BO-150 (depth 389 m), upper view, ×101

10 — *Gnathodus* aff. *typicus* COOPER, 1939; BO-162 (depth 367.5 m), upper view, ×87

11 — *Apatognathus* sp.; BO-150 (depth 500 m), lateral view, ×61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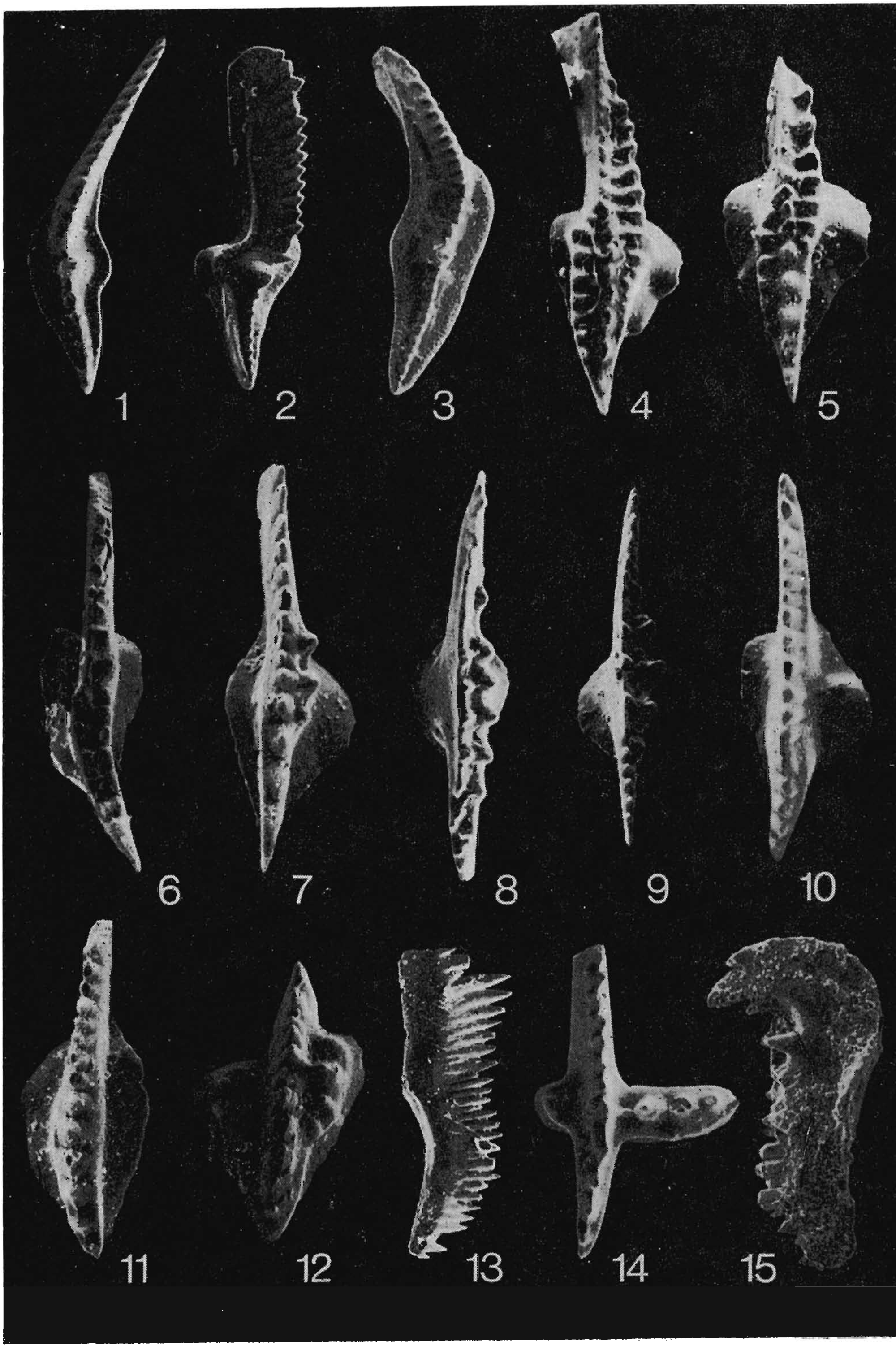
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AGE: The precise correlation of the *austini* Zone to the ammonoid sequence as well as to the stratigraphical scheme used in Belgium is not yet practicable. The first occurrence of *Gnathodus bilineatus bilineatus* that marks the upper limit of this zone remains in fact the only datum for such correlation. In Belgium and Germany, however, the data supporting the range of this very important taxon are not strong (*cf.* MEISCHNER 1970; PAPROTH 1970), or are based only on a preliminary recognition (GROESSENS 1974; CONIL, GROESSENS & PIRLET 1976). According to VOGES (1960), *G. bilineatus bilineatus* has its first appearance within the *Entogonites nasutus* Zone (*Peδ*) in West Germany. Hence, the *austini* Zone would be contained in the interval occurring between the *Peγ* Zone and the *Peδ* Zone (Text-fig. 4). In Belgium it corresponds to the Middle Visean (*V2*).

LOCALITIES: Boreholes Sosnowiec *IG-1, BO-150, BO-149, BO-162,* and *BE-75.*

BILINEATUS PARTIAL-RANGE ZONE

SYNONYMS: *Bilineatus-delicatus* s. 1. Zone; ADRICHEM BOOGAERT (1967).
Gnathodus commutatus commutatus-Zone; MARKS & WENSINK (1970).
Gnathodus bilineatus bilineatus-Zone; MEISCHNER (1970).
Gnathodus commutatus commutatus-Zone; BOERSMA (1973).
Zone á *Gnathodus bilineatus bilineatus*; BOYER & *al.* (1974).
Gnathodus bilineatus bilineatus-Zone; EBNER (1977).
Zone á *Gnathodus commutatus commutatus-Gnathodus bilineatus*; PERRET (1977).
Gnathodus commutatus commutatus-Zone; BUCHROITHNER (1979).
Gnathodus bilineatus Zone; HIGGINS & WAGNER-GENTIS (1982).

DEFINITION: Interval from the first occurrence of the zonal marker *Gnathodus bilineatus bilineatus* to the first occurrence of *Paragnathodus nodosus*.

ASSOCIATED FAUNA: The conodont fauna of this zone is undiversified and usually occur in small numbers. Taxa that range throughout the *bilineatus* Zone are only *G. bilineatus bilineatus*, *Paragnathodus commutatus*, and *Gnathodus girtyi girtyi* which appears simultaneously with the zonal marker. Other gnathodids as *G. symmutatus*, *G. homopunctatus*, and *G. mermaidus* occur but erratically, while *G. austini* sp. n. and *G. praebilineatus* sp. n. terminate within this zone. Similar to that

PLATE 16

1 — *Palmatolepis gracilis gracilis* BRANSON & MEHL, 1934; BO-150 (depth 580 m), ×42
2 — *Palmatolepis gracilis sigmoidalis* ZIEGLER, 1962; WB-64 (depth 174.5 m), ×62
3 — *Palmatolepis gracilis expansa→gonioclymaniae*; BO-150 (depth 580 m), ×68
4—5 — *Bispathodus ultimus* (BISCHOFF, 1957); *4* from BK-318 (depth 662 m), ×45; *5* from WB-64 (depth 174.5 m), ×61
6 — *Bispathodus jugosus* (BRANSON & MEHL, 1934); BK-318 (depth 662 m), ×66
7 — *Bispathodus bispathodus* ZIEGLER, SANDBERG & AUSTIN, 1974; BK-318 (depth 662 m), ×90
8 — *Bispathodus costatus* E.R. BRANSON, 1934, Morphotype *2*; BO-150 (depth 580 m), ×46
9 — *Bispathodus aculeatus aculeatus* (BRANSON & MEHL, 1934); WB-64 (depth 174.5 m), ×68
10—11 — *Bispathodus stabilis* (BRANSON & MEHL, 1934); from Sosnowiec (depth 1984 m), *10* — ×53; *11* — ×88
12 — *Protognathodus* sp.; WB-64 (depth 174.5 m), ×70
13 — „*Spathognathodus*" *strigosus* (BRANSON & MEHL 1934); BK-318 (depth 662 m), lateral view, ×31
14 — „*Spathognathodus*" *disparilis* (BRANSON & MEHL, 1934); BO-150 (depth 580 m), ×55
15 — *Bispathodus aculeatus plumulus* RHODES, AUSTIN & DRUCE, 1969; Sosnowiec (depth 1980.5 m), lateral view, ×75

All upper views, except Figs 13 and 15

was the occurrence of *M. beckmanni*, which through the transitional specimens, gave rise to *M. bipluti* (*cf.* BEŁKA 1983).

AGE: The stratigraphic position of both, lower and upper limits of this zone is doubtful. Remarks on the first appearance of *Gnathodus bilineatus bilineatus* are given under characteristics of the preceding zone. The upper limit of the *bilineatus* Zone is placed either in the middle of the *Goβ* Zone in West Germany (MEISCHNER 1970) or already within the *Goα* Zone in Belgium (CONIL, GROESSENS & PIRLET 1976). It was previously supposed (BEŁKA 1982) that the divergence in stratigraphic location of the appearance of *P. nodosus* is considered to have resulted from the errors in correlation of particular conodont subdivisions with standard ammonoid zonation.

LOCALITIES: Boreholes *BO-162* and *BE-75*.

REMARKS: The upper limit of the *bilineatus* Zone has not been recognized in the investigated sections. This is because that some of them, owing to the post-Variscan erosion, do not range as high as the first appearance of *P. nodosus*. In other sections, however, the critical intervals are characterized by flysch deposits (*cf.* Text-fig. 5) and conodonts have not been found there.

REGIONAL CORRELATION

The Lower Carboniferous deposits pierced by boreholes in the area between Olkusz and Sosnowiec represent, within the Moravia-Silesia Basin, the marginal part of the carbonate platform and its transition to the basinal realm (BEŁKA 1984). The platform margin and the upper foreslope deposits are mainly composed of oolithic, bioclastic (*see* Pl. 18) and lithoclastic carbonates that exibit a texture ranging from grainstone to packstone. The basinal and lower foreslope facies is developed as black shales and spiculitic wackestones interbedded with allodapic beds (*see* Pl. 19). Sometimes, the latter lithofacies is associated with volcanogenic deposits (*see* Pls 20 and 21) forming two, red-colored horizons. They both are useful as stratigraphic markers dated for the *anchoralis* Zone (*cf.* Text-fig. 5). In the investigated area, the flysch deposits were observed in two boreholes only (Sosnowiec *IG-1*, and *BK-318*). These deposits represent a distal extent of turbidities and onlap both the basinal and platform sequence.

PLATE 17

1—2 — *Polygnathus znepolensis* SPASOV, 1965; from Sosnowiec (depth 1984 m), *1* — ×54; *2* — lower view, ×53

3 — *Polygnathus collinsoni* DRUCE, 1969; Sosnowiec (depth 1980.5 m), ×39

4—6 — *Polygnathus vogesi* ZIEGLER, 1962; from WB-64 (depth 174.5 m), *4* — ×83; *5* — lower view, ×66; 6 — ×58

7 — *Pseudopolygnathus marburgenesis marburgenesis* BISCHOFF & ZIEGLER, 1950; BK-318 (depth 662 m), ×36

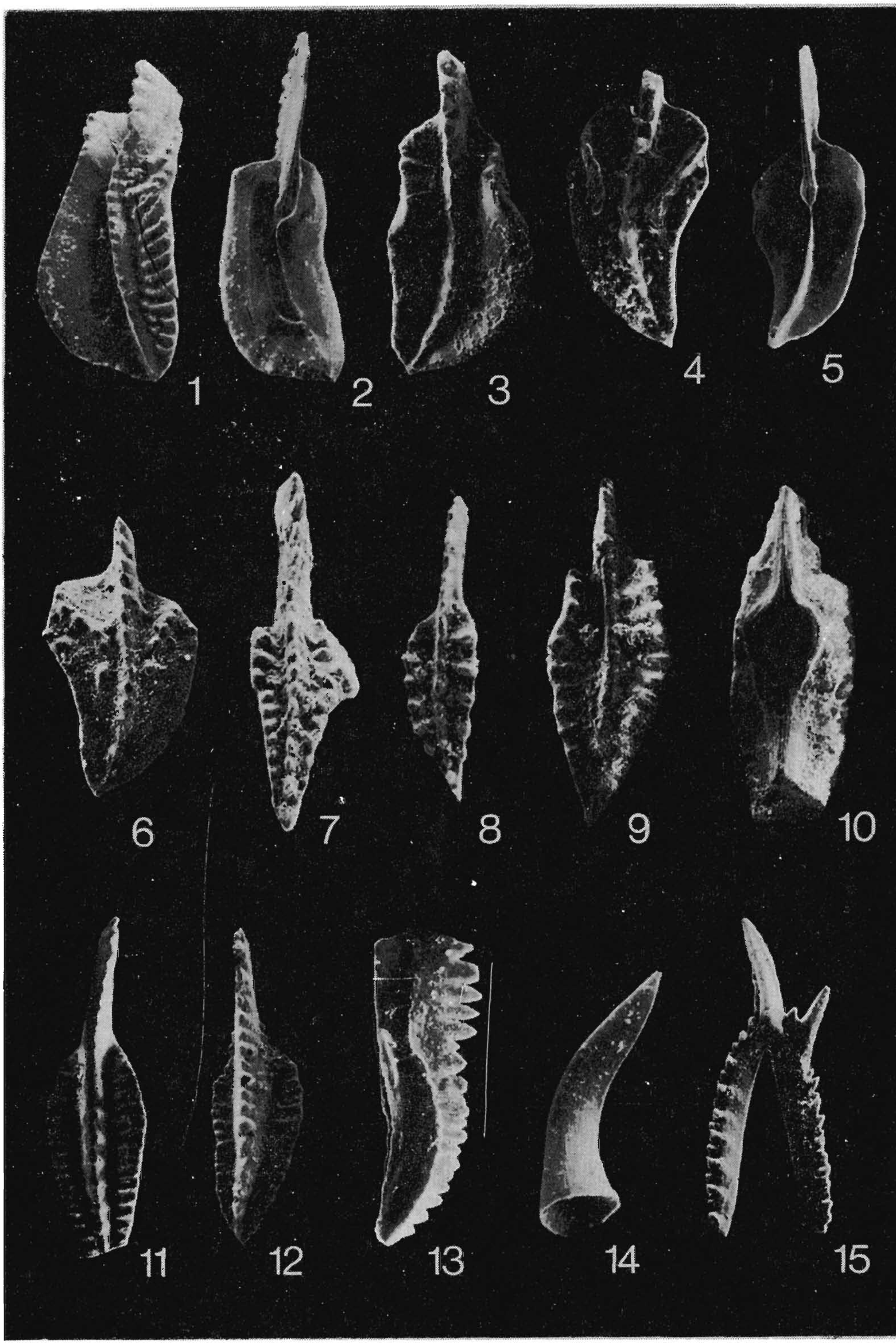
8 — *Pseudopolygnathus dentilineatus* BRANSON, 1934; Sosnowiec (depth 1984 m), ×73

9—10 — *Polygnathus* cf. *longiposticus* BRANSON & MEHL, 1934; from Sosnowiec (depth 1978 m), *9* — ×34; *10* — juvenile specinem, lower view, ×54

11—13 — *Polygnathus procera* SANNEMANN, 1955; *11* from WB-64 (depth 174.5 m), ×53; *12* from Sosnowiec (depth 1984 m), ×67; *13* from Sosnowiec (depth 1984 m), lateral view, ×77

14 — *Acodina* sp.; WB-64 (depth 174.5 m), lateral view, ×89

15 — *Apatognathus varians* BRANSON & MEHL, 1934; BO-150 (depth 580 m), lateral view, ×66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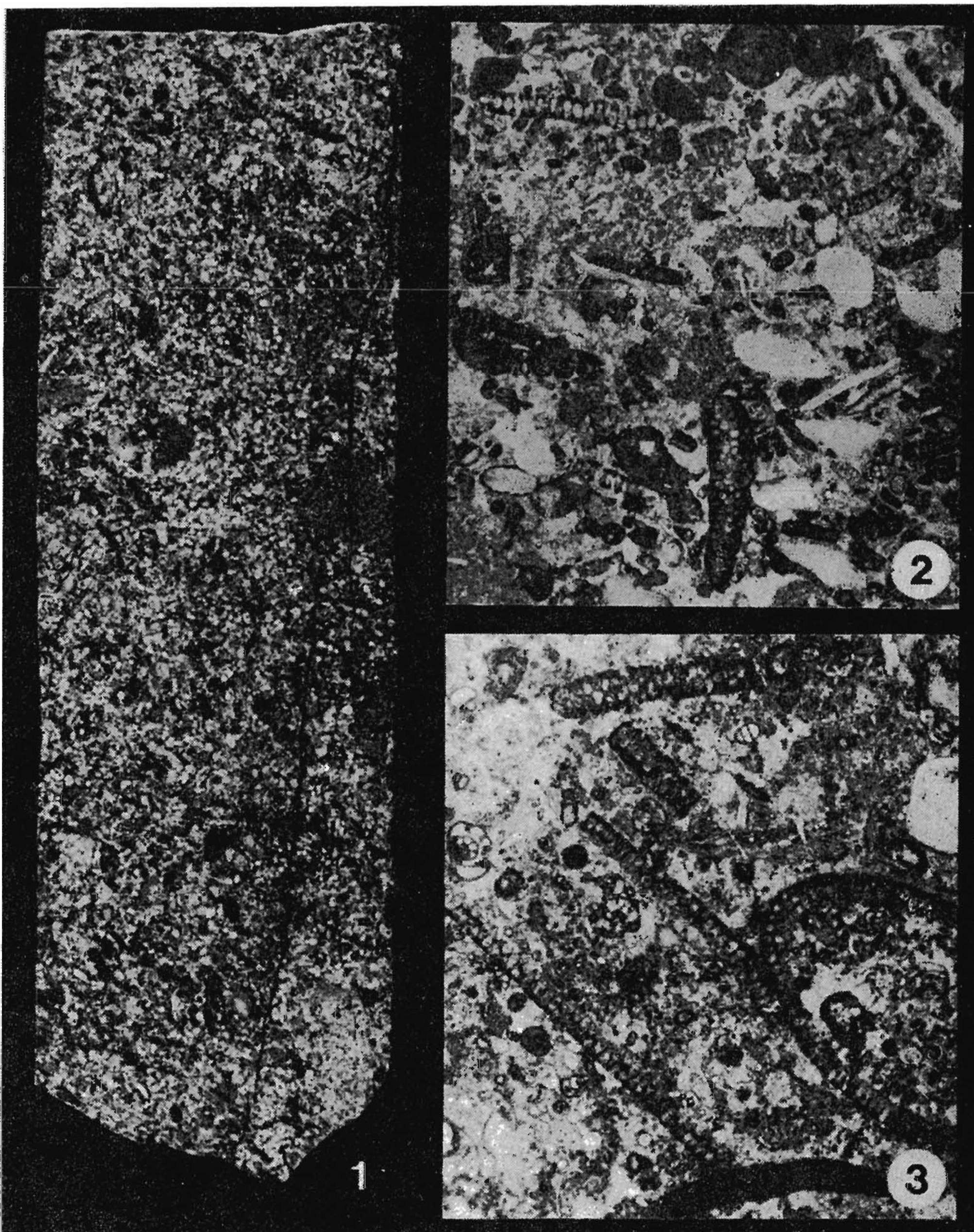
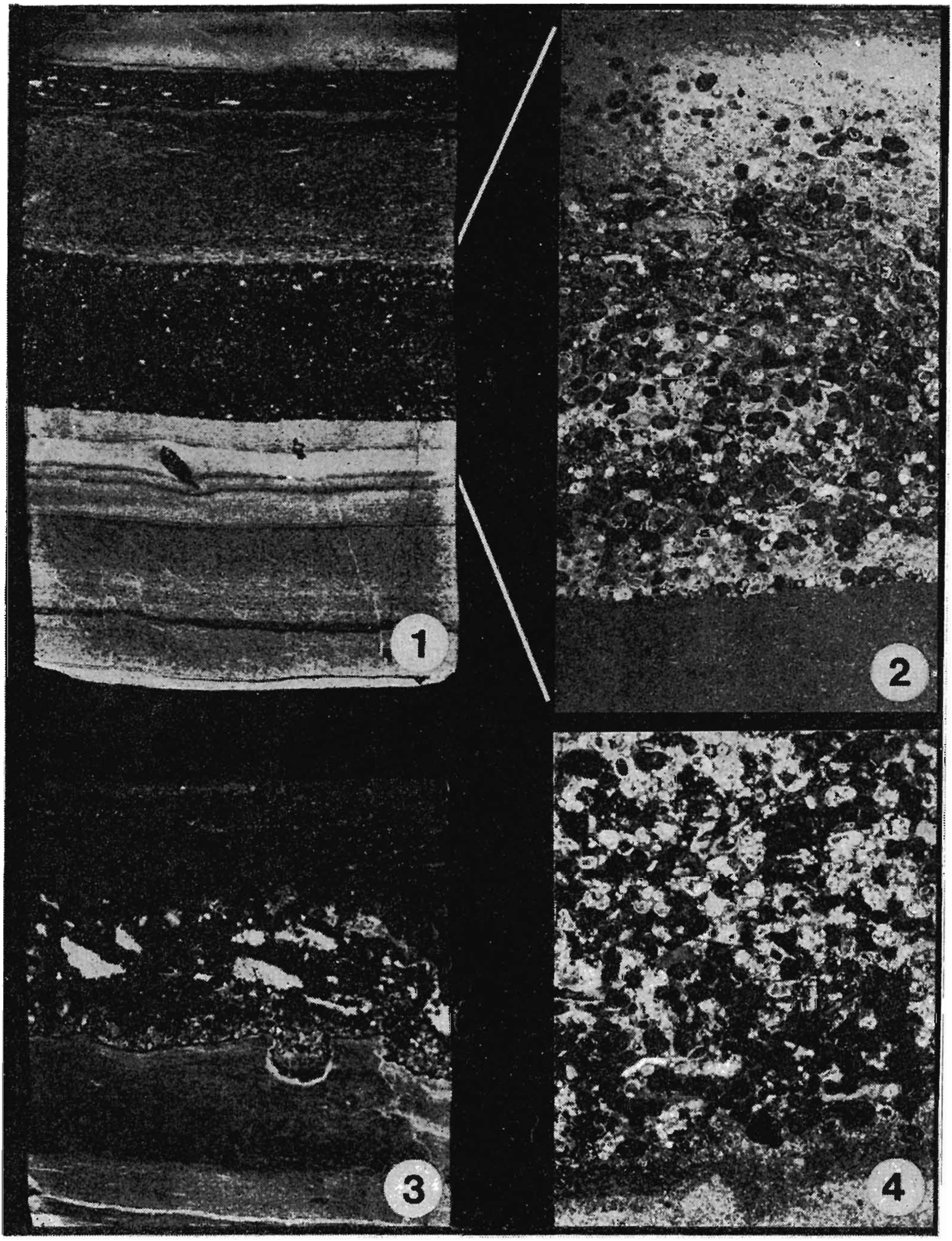


Foreslope facies

1 — Poorly-sorted ooid-bioclastic packstone with lithoclasts of oolitic grainstone; the dominant skeletal fragments are pieces of echinoderms and dasycladacean alga *Koninckopora*; BO-145a (depth 141 m), vertical core slab; nat. size

2 — Bioclastic packstone with abundant fragments of *Koninckopora*, echinoderms, brachiopods, and foraminifers; BO-149 (depth 180 m); thin section, ×7

3 — Dasycladacean-rich packstone containing well-preserved fragments of *Koninckopora* and various small foraminifers; BO-149 (depth 180 m); thin section, ×12



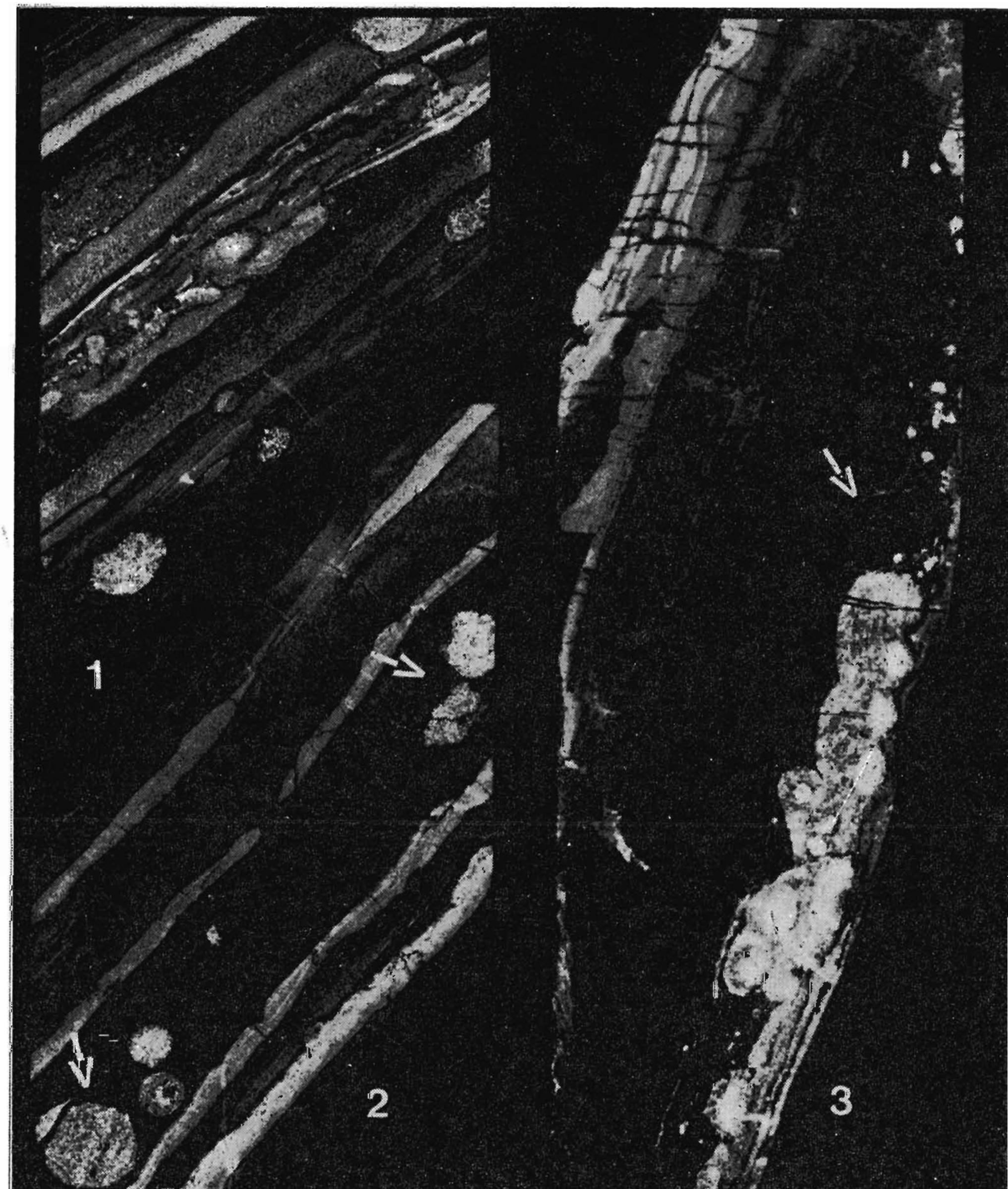
Basinal facies

1 — Spiculitic wackestone interbedded with thin layer of ooid-bioclastic packstone; BO-145a (depth 245.2 m), vertical core slab; ×1.3

2 — Interbed *from* Fig. 1 interpreted as contourite; it is non-graded, has both lower and upper contacts sharp, and displays horizontal grain orientation; thin section; ×4.6

3 — Erosional contact between spiculitic wackestone and the allodapic bed containing primarily ooids and fragments of reworked tuffite layer (*white*); BO-145a (depth 243 m), vertical core slab; ×1.3

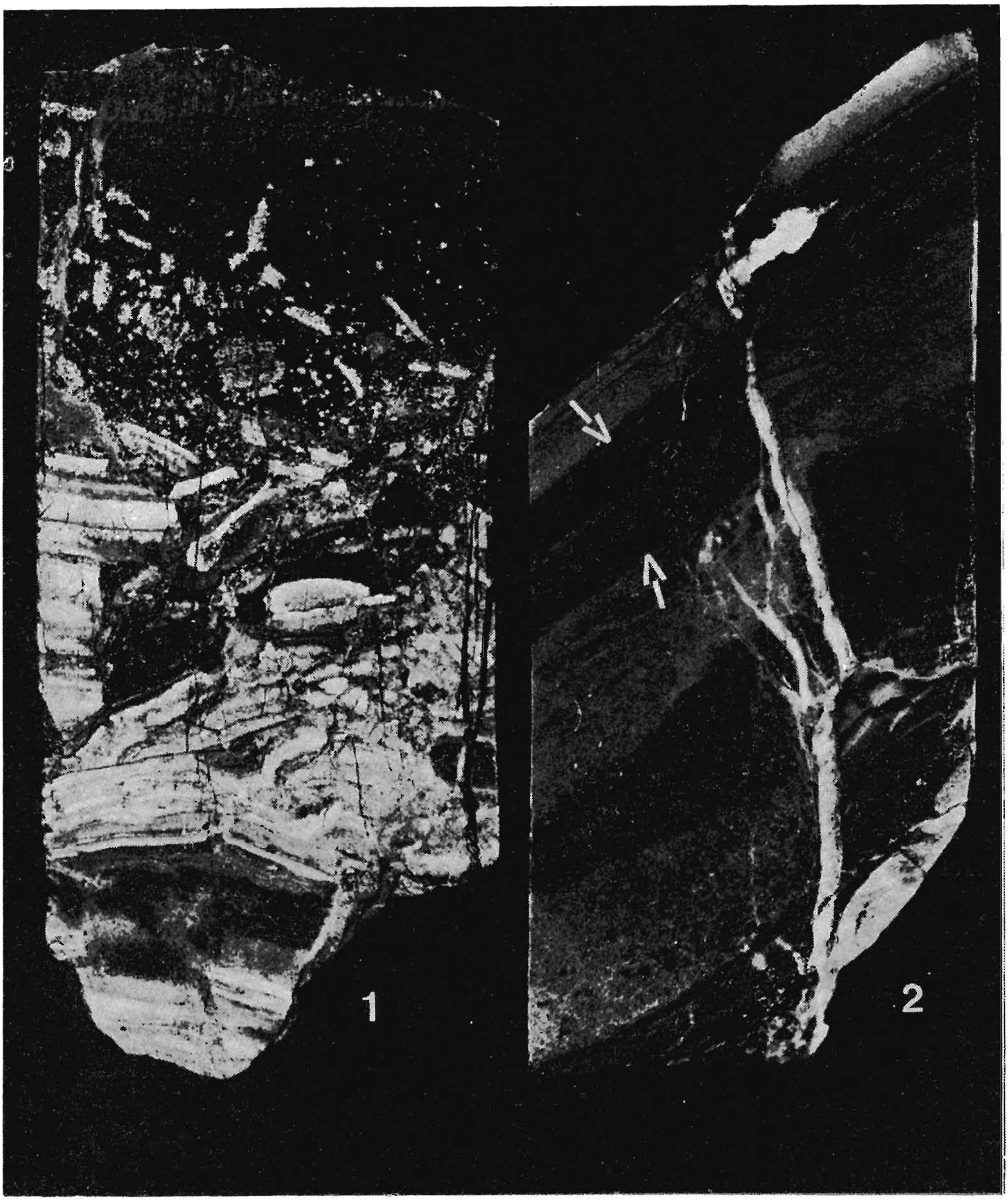
4 — Lower part of allodapic bed overlying spiculitic wackestone; note the selective silification of allochems (*white*); BO-150 (depth 334 m); thin section, ×4



Volcanogenic deposits

1-2 — Fragments of volcanogenic horizons, to show the occurrence of tephra; black layers consisting of ash particles and radiolarians contain completely altered acceretionary lapilli (*arrowed*); white layers are carbonate, partly silicified, with only small admixture of pyroclasts; BO-150 (depth 407 m), vertical core slabs; ×1.4

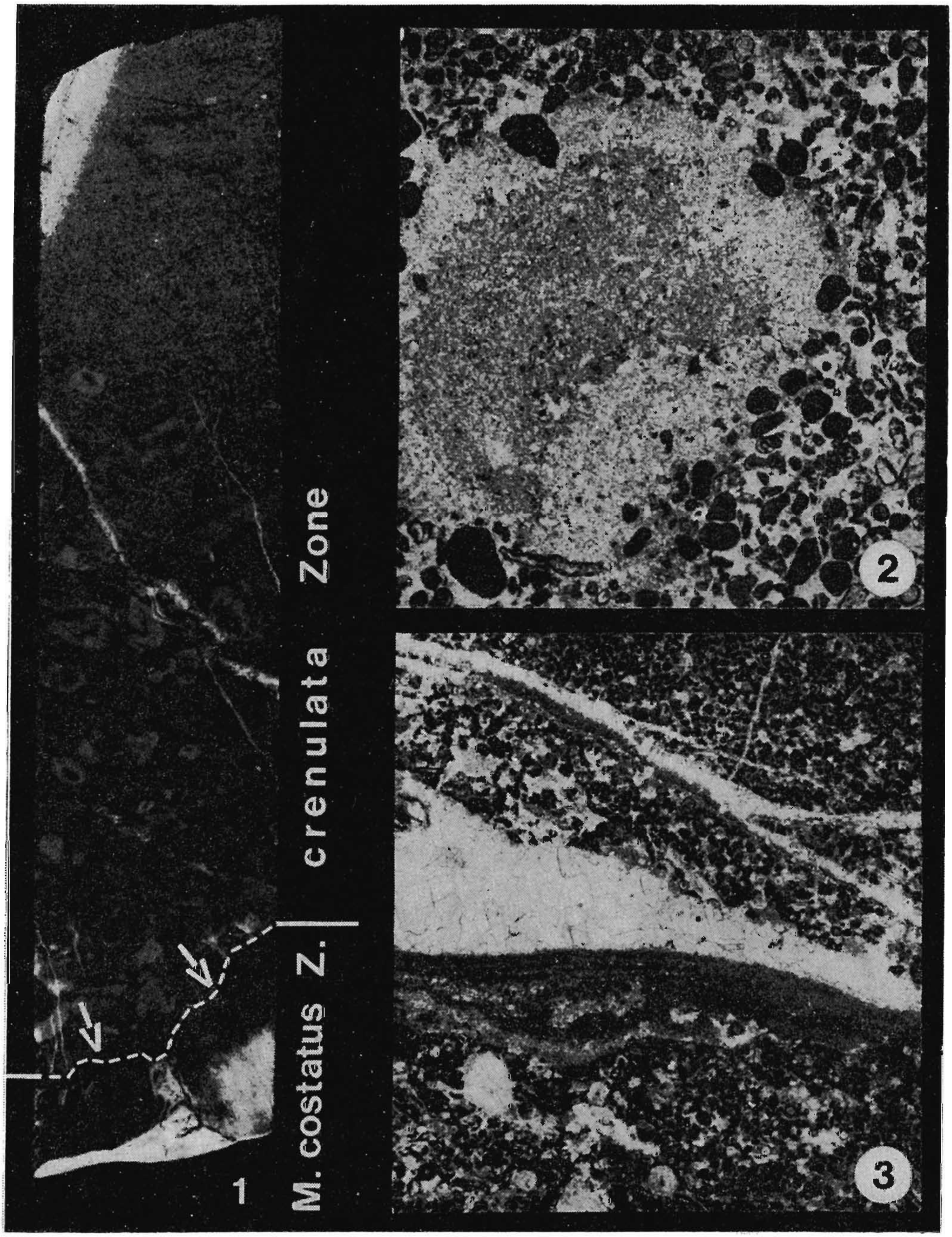
3 — Accretionary lapilli at the bottom of allodapic graded bed; note the presence of convolute bedding in the top of this bed; one of the lapilli (arrowed) displays primary composition, *i.e.* volcanic glass with cherty silica; BO-150 (depth 411 m), vertical core slab; ×1.3



Volcanogenic deposits

1 — Tephra-rich radiolarian wackestones, strongly silicified, destroyed by turbidity current; note the incorporation of reworked fragments of the volcanogenic layers in the graded set of the overlying allodapic bed; BO-150 (depth 419 m), vertical core slab; ×1.3

2 — Ash particles accumulation (*arrowed*) following the convolute bedding set within the allodapic bed; BO-150 (depth 407 m), vertical core slab; ×1.2

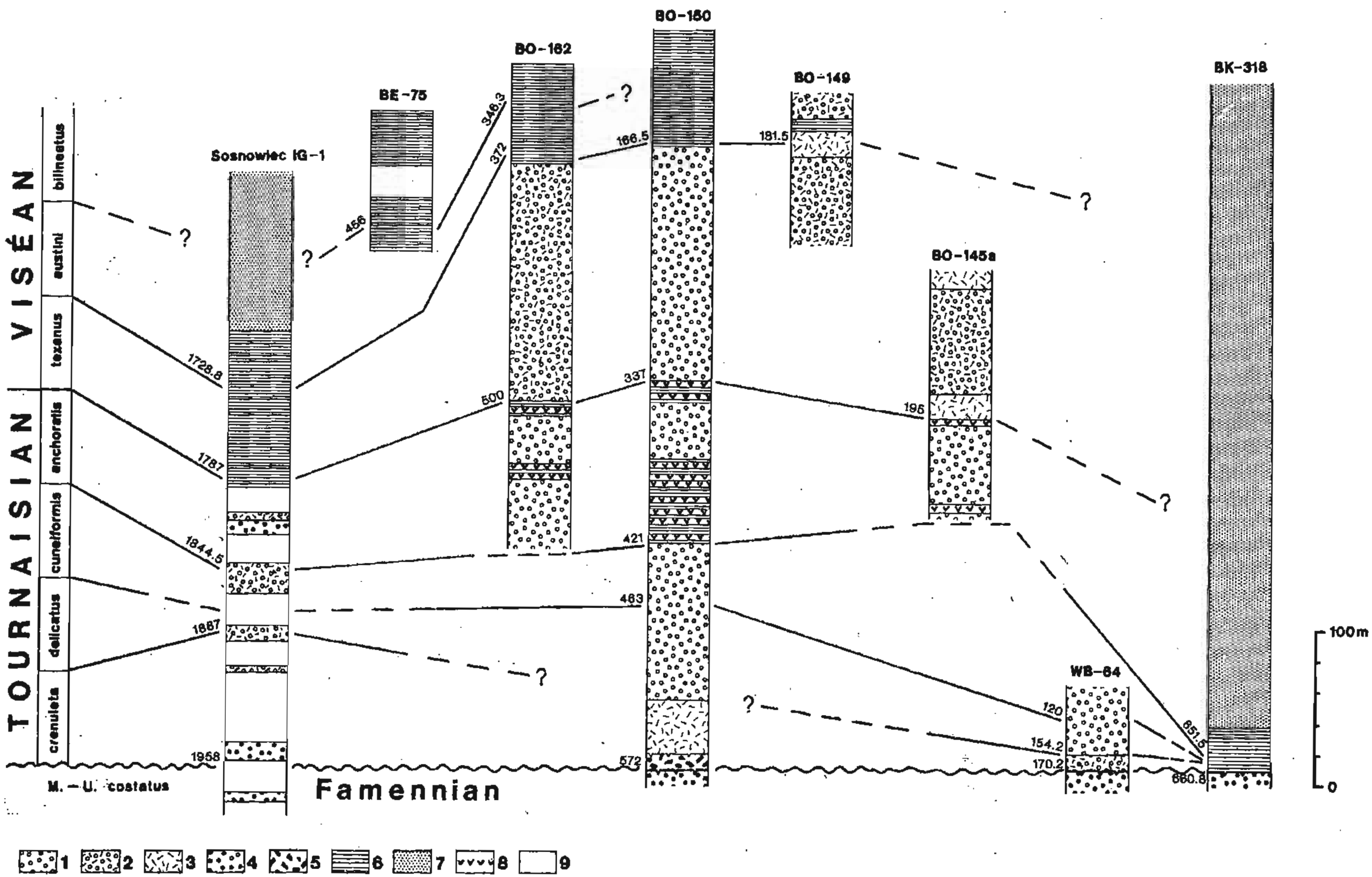


1 — Erosional contact (*arrowed*) between the uppermost Devonian (Middle *costatus* Zone) peloidal grainstone and Lower Carboniferous (*crenulata* Zone) ooid-bioclastic grainstone; note the presence of weathered lithoclasts of the Devonian substrate above the contact; BO-150 (depth 572 m), vertical core slab; ×0.7

2 — Crystal silt filling the void within the fine-grained peloidal grainstone that form the top of the Devonian sequence; BO-150 (depth 577 m); thin section, ×10

3 — Horizontal layers of crystal silt followed by blocky cement in the fracture within the top of the Devonian sequence; BO-150 (depth 573 m); thin section, ×7

Stratigraphy and correlation of investigated boreholes based on contained conodont fauna



Location of boreholes given in Text-fig. 1; depth of zonal boundaries given in meters beside columns

1 — oolitic grainstones; 2 — ooid-bioclastic grainstones and packstones; 3 — bioclastic grainstones and packstones; 4 — peloidal grainstones; 5 — lithoclastic grain stones; 6 — spiculitic wackestones with allodapic limestones (except of borehole *BK-318*: black shales); 7 — shales and sandstones (flysch series); 8 — volcanogenic deposits; 9 — no core (except of borehole *BE-75*: Permian karstic infilling)

The biostratigraphic study based on conodonts allowed to recognize that the main lithofacies units are diachronous in their character (BEŁKA 1984), what precludes a simplistic correlation of lithological and biostratigraphic units. The evolution and facies pattern of this Dinantian platform have recently been described (BEŁKA 1985), and this shows a permanent retreat of the platform with a lack of progradation effect, as well as its final drowning. The tectonic subsidence was a major factor controlling the platform evolution.

The Tournaisian deposits occur in the whole investigated area, and they comprise four conodont zones, *crenulata*, *delicatus*, *cuneiformis*, and *anchoralis*. The thickness of these deposits is variable, showing clearly dependence upon sedimentary environment. In the section *BK-318*, the Tournaisian developed as basinal shales is a dozen or so meters thick, though its biostratigraphic recognition is fragmentary (*cf.* BEŁKA 1984). Contrary, the deposits of the platform margin reach a thickness of 240 m. The thickness differences between carbonate platform an basinal facies, manifested also during Viséan time, are more distinct when the particular conodont zones are examined (*see* Text-fig. 5).

Due to the apparently diachronous facies development, both the Tournaisian/Viséan boundary as well as other zonal limits fall in individual boreholes within different lithofacies units.

The deposits overlying the Tournaisian/Viséan boundary represent only the lower portions of the Viséan sequence that along with younger Carboniferous strata has suffered the post-Variscan erosion in many places. Finally, the Viséan rocks are usually covered by the Permian conglomerates, or overlain by the Lower Triassic (Roth) dolomites in places which during Permian time formed morphological elevations. In fact, the section Sosnowiec *IG-1* is the only one, in which the whole Viséan sequence is preserved. However, considering the age, the precise dating is possible only for the lower, carbonate part of the sequence (Text-fig. 5). In the overlying flysch deposits no conodonts have been found, and within these very deposits the Viséan/Namurian boundary runs. As long as the precise position of this boundary remains unknown, it is difficult to estimate the total thickness of the Viséan sequence in the studied area. The thickness of the Viséan carbonates ranges here from 90 to 200 m, being dependent upon sedimentary environment, and it becomes in the platform margin facies three times as great as in the basinal facies. The contact between the carbonates and the flysch deposits is diachronous throughout the studied area (Text-fig. 5). If the carbonates terminate within the *austini* Zone in the borehole Sosnowiec *IG-1*, then in the vicinity of Olkusz they are still present in the *bilineatus* Zone.

THE DEVONIAN/CARBONIFEROUS CONTACT

The problem of the relation of the Devonian to the Lower Carboniferous in the northeastern part of the Moravia-Silesia Basin has long subjected to extensive discussions (JAROSZ 1926; RUTKOWSKI 1928; SIEDLECKI 1954; ZAJĄCZ-

KOWSKI 1964). There was a disagreement on the subject as the stratigraphic data based on the benthic fauna occurrences were used. More recently, a common opinion was presented (BOJKOWSKI 1972; JURKIEWICZ & ŻAKOWA 1972; KICUŁA & ŻAKOWA 1972) that the stratigraphic gap occurs between the Devonian and the Lower Carboniferous deposits in the area extending from the Upper Silesia Coal Basin to the Miechów Upland (northeast of Cracow). The size of the gap has not been precisely defined, except of the borehole Węgrzynów *IG-1*, where the recognized conodont sequence was lacking in the lower part of the Tournaisian (CHOROWSKA 1972). Only in the Krzeszowice area (Text-fig. 1), the Devonian/Carboniferous transition was considered to be continuous (*cf.* BOJKOWSKI 1972); the latter opinion derived from the brachiopod investigations of JAROSZ (1926) seems to be, however, questionable. This is because the ages suggested by JAROSZ's investigations for several localities occurring near Krzeszowice have not been confirmed by conodont fauna recently reported (GROMCZAKIEWICZ-ŁOMNICKA 1979).

Three boreholes (100% core in *BO-150, WB-64, BK-318*; *see* Text-figs 1 and 5) in the Sosnowiec and Olkusz area (BEŁKA 1984) gave the opportunity to study the relation of the Devonian to the Lower Carboniferous. The contact marked by a change in lithology is of erosional nature (Pl. 22, Fig. 1) and it is associated by a significant stratigraphic gap occurring between the Devonian and the Lower Carboniferous deposits. In all these boreholes the gap appears to cover almost the same interval. The top of the Devonian sequence yields very abundant, high-diversity conodont fauna (Text-fig. 6) indicative of the Middle and/or Upper *costatus* Zone (*cf.* ZIEGLER, SANDBERG & AUSTIN 1974; SANDBERG & ZIEGLER 1979).

Boreholes	BO-150				WB-64		BK-318		Sosnowiec IG-1			
Conodonts / Depth (in m)	580	577	575	573*	174.5	172*	662	661*	1984	1982.5	1980.5	1978*
Bispathodus aculeatus aculeatus	•	—	—	—	•	•	•	•	—	—	—	—
B. aculeatus anteposicornis	—	—	—	—	•	—	—	—	—	—	—	—
B. aculeatus plumulus	—	—	—	—	—	—	—	—	—	—	•	—
B. bispathodus	•	—	—	—	•	•	•	•	—	—	—	—
B. costatus	•	•	•	—	•	•	•	•	•	•	•	•
B. jugosus	—	—	—	—	—	—	•	—	—	—	—	—
B. stabilis	—	—	—	—	—	•	•	•	•	•	•	—
B. ultimus	—	—	—	—	•	•	•	•	—	—	—	—
Palmatolepis gracilis gracilis	•	•	•	—	—	•	•	•	—	—	—	—
Pa. gracilis sigmoidalis	•	—	•	•	•	•	•	•	•	—	—	—
Pa. gracilis expansa → gonioclymeniae	•	—	—	—	—	—	—	—	—	—	—	—
Polygnathus collinsoni	—	—	—	—	—	—	—	—	—	—	•	—
Po. communis communis	•	—	—	—	•	•	•	•	—	—	—	—
Po. delicatulus	•	—	—	—	•	—	•	•	•	•	•	—
Po. vogesi	•	—	—	—	•	—	—	•	—	—	—	—
Po. znepolensis	•	—	—	—	—	•	—	•	•	—	•	—
Protognathodus meischneri	—	—	—	—	—	—	—	—	•	—	—	—
Pseudopolygnathus dentilineatus	•	—	—	—	—	—	—	•	•	—	—	—
Ps. marburgensis marburgensis	—	—	—	—	—	—	•	—	—	—	—	—

Fig. 6. Distribution of conodonts in the uppermost part of the Devonian sequence in the Olkusz and Sosnowiec area; asterisked are the samples taken just below the Devonian/Carboniferous contact

Above the contact, however, conodonts are rather rare but the presence of siphonodellids as *S. crenulata*, *S. cooperi* Morphotype *2*, *S. quadruplicata* and *S. lobata*, along with the analysis of the whole Lower Carboniferous conodont sequence (BEŁKA 1984) allowed to attribute the beds overlying the contact to the *crenulata* Zone. It is not unlikely that in the borehole *BK-318* the Lower Carboniferous sedimentation could start earlier, with the *sandbergi* Zone. Similar to that are results from the borehole Sosnowiec *IG-1*, in which the first accessible Lower Carboniferous sample represents the *sandbergi* or *crenulata* Zone but in this section the Devonian/Carboniferous boundary falls within the interval (depth 1957.5 — 1978 m) where no core has been obtained (*cf.* Text-fig. 5). Nevertheless, the occurrence of the gap separating the Devonian from the Lower Carboniferous is also very probable there (*cf.* BEŁKA 1984).

Besides the biostratigraphic data the gap is indicated by lithological evidences. At the contact, the lithology of the Lower Carboniferous deposits distinctly differs from that of the Devonian. The Tournaisian limestones contain cm-size weathered lithoclasts of the Devonian substrate (*see* Pl. 22, Fig. 1). The top of the Devonian sequence displays features manifesting an emersion event (*cf.* BEŁKA 1984), in the time of which these rocks were exposed to the atmosphere influences and their weathering began. The limestones underwent dissolution producing numerous voids which subsequently were either recemented or filled by red clays. The bottom of voids is usually geopetally covered by crystal silt followed by blocky cement (Pl. 22, Fig. 3), and sometimes gravitional cements are also present. Moreover, there are many voids completely filled by crystal silt (Pl. 22, Fig. 2) that penetrates even 2.5 m below the contact surface. This kind of internal sediment, attributable to vadose conditions (*cf.* DUNHAM 1969), is considered to be diagnostic of subaerial exposure (*cf.* FLÜGEL 1982).

The recognized stratigraphic gap between Devonian and Carboniferous deposits is restricted not only to the Sosnowiec and Olkusz area. It has already been shown by the data from the above mentioned borehole Węgrzynów *IG-1* (situated 40 km NE of Cracow), but its poor sampling does not precise the size of the gap recognized by CHOROWSKA (1972). In the Krzeszowice area, the presence of this gap is also suspectable. This possibility is apparent when the paleogeographic location of this area within the interior of the carbonate platform is taken into account (*cf.* BEŁKA 1985). Some evidences have already been given also by GROMCZAKIEWICZ-ŁOMNICKA (1979), who working on several Devonian and Lower Carboniferous small outcrops has not found any deposits that would be younger than the *sulcata* Zone and unquestionably older than the *crenulata* Zone. Two outcrops (known as "Łom Góreckiego" and "Wapienie nad Pstrągarnią") attributed to the *Siphonodella-Ps. triangulus inaequalis* Zone and to the *Siphonodella-Ps. triangulus triangulus* Zone respectively have not been precisely dated, and in fact, they may be younger, as it is discussed elsewhere (BEŁKA 1984).

Acknowledgements

The author offers his thanks to Professor M. SZULCZEWSKI, University of Warsaw, for advise and encouragement; to Professor A. RADWAŃSKI, University of Warsaw, for suggesting many improvements to the manuscript; to Mr. K. POTOCKI, Warsaw, President of the Potocki's Grant, for sponsoring the stay in Belgium and England to study conodont collections; to Dr. R.L. AUSTIN, University of Southampton, and to Dr. E. GROESSENS, Geological Survey of Belgium, for making the conodont collections available for comparative studies. Thanks are also due to Dr. K. BOJKOWSKI, S. SKOMPSKI, M. Sc., R. GAWROŃSKA, M. Sc., J. SOBOŃ-PODGÓRSKA, M. Sc., and L. SZOSTEK, M. Sc., for their help during all phases of the study.

The Geological Enterprise, Cracow, and the Silesian Branch of the Geological Survey of Poland kindly allowed the author to sample the boreholes from the Olkusz and Sosnowiec area.

The photos of borehole cores were taken by Mrs. K. ZIELIŃSKA, and the scanning-electron-micrographs by Miss E. KLICHOWICZ.

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Z. BEŁKA

STRATYGRAFIA KONODONTOWA DOLNEGO KARBONU PÓŁNOCNO-WSCHODNIEJ CZĘŚCI BASENU MORAWSKO-ŚLĄSKIEGO

(Streszczenie)

W utworach węglanowych nawierconych pod osadami permu i triasu w okolicach Olkusza i Sosnowca (*patrz* fig. 1) stwierdzono występowanie dolnokarbońskiej fauny konodontowej, która dokumentuje wiek tych osadów na środkowy turniej — górny wizen. Ogółem uzyskano blisko 2400 konodontów (1600 platformowych i 800 gałązkowych), lecz przeciętna frekwencja w próbkach była niska i wynosiła 7—10 elementów na 1 kg skały, a przeciętny stosunek elementów platformowych do gałązkowych wynosił 1,5: 1 (fig. 2). Badany zespół konodontów (*patrz* fig. 3 oraz pl. 1—15) jest bardzo podobny do faun konodontowych znanych z dolnokarbońskich (zarówno basenowych jak i platformowych) osadów innych regionów Europy i Ameryki Północnej (*por.* VOGES 1959; GROESSENS 1974; PERRET 1977; LANE, SANDBERG & ZIEGLER 1980). Jedynie wśród gnathodidów stwierdzono trzy formy, które wypełniają lukę, jaka dotychczas istniała pomiędzy gatunkami turnejskimi a środkowowizeńskimi. Formy te opisano jako gatunki nowe: *Gnathodus austini* sp. n., *Gnathodus praebilineatus* sp. n., oraz *Paragnathodus cracoviensis* sp. n.

W celu skorelowania badanych profili przyjęto (*patrz* fig. 4) wstępną standardową zonację konodontową dolnego karbonu (SANDBERG & *al.* 1978; LANE, SANDBERG & ZIEGLER 1980). Zaproponowano jej modyfikację oraz rozszerzono schemat o dwa stratygraficznie wyższe poziomy: *austini i bilineatus*, obejmujące swym zasięgiem część środkowego i górnego wizenu. Przeprowadzona korelacja ujawniła na badanym obszarze diachroniczny przebieg facji dolnego karbonu (*patrz* fig. 5).

W czterech spośród analizowanych wierceń udało się również ustalić położenie kontaktu pomiędzy osadami dewońskimi i karbońskimi (*patrz* fig. 6 oraz pl. 16—22). Kontakt ten ma charakter erozyjny i towarzyszy mu luka stratygraficzna sięgająca od środkowego lub górnego poziomu *costatus* do poziomu *crenulata*, chociaż miejscami sedymentacja osadów dolnego karbonu mogła rozpocząć się wcześniej, w dobie *sandbergi*.