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Upper Devonian of Western Pomerania

ABSTRACT: Within the generally carbonate and mixed carbonate-siliciclastic sequence pierced by deep boreholes, 21 conodont zones are recognized from the Frasnian *punctata* Zone up to the lower Tournaisian *sandbergi* Zone in Western Pomerania, northwestern Poland. Four Famennian conodont species are established as new: *Polygnathus limbatus* sp. n., *Polygnathus pomeranicus* sp. n., *Polygnathus praecursor* sp. n., and *Alternognathus costatiformis* sp. n.

Lateral relationship of litho- and biofacies as well as their vertical succession are recognized within the Late Devonian sedimentary environments. Six conodont biofacies (palmatolepid-polygnathid, polygnathid-palmatolepid, icriodid-polygnathid, polygnathid, polygnathid-bispathodid, and bispathodid) and some mixed conodont biofacies are documented in settings ranging from offshore pelagic to shallow nearshore. The distribution of the Late Devonian litho- and biofacies within the epicratonic Pomeranian sea was influenced by the location of the hinterland to the north (Fennoscandian High) and to the east (Mazurian and/or Byelorussian High) which controlled a north- and eastwardly sea shallowing.

The Late Devonian history of Western Pomerania underwent evolution from extremely shallow water and coastal environments in the earliest Frasnian, through deeper environments during the rest of the Frasnian and early Famennian up to the *rhomboidea* Chron. The presence of Famennian stromatoporoid-coral-crinoid-bryozoan buildups is noticeable in the Early and Middle *marginifera* Chrons. Extensive shallow water and coastal environments reappeared in the late Famennian, precisely since the Latest *marginifera* Chron up to the Middle *expansa* Chron. At the end of the Famennian, beginning with the Late *expansa* Chron, an open sea environment became prevalent almost over the whole area and continued up to the early Tournaisian.

A sequence of 13 events, both eustatic sea-level changes and epeiric movements, as well as those of biotic nature, is revealed and dated in terms of the worldwide standard conodont zonation.

INTRODUCTION

The Devonian and Lower Carboniferous rocks of Western Pomerania, northwestern Poland, are completely covered by younger sediments of a considerable thickness, and have been reached only by exploration drillings. The present-day occurrence of the Devonian and Lower Carboniferous sediments in Western Pomerania is an effect of Late Carboniferous tectonics and subsequent erosion. Their northeastward extent is sharply delineated by a northwest-southeast striking tectonic line (*see* Text-figs 1-2). They are thought to continue towards the northwest, where they have been discovered in the Baltic Sea floor (POŻARYSKI & WITKOWSKI 1990), as well as to southwest towards the Sudety Mountains.

The Devonian and Carboniferous deposits of Western Pomerania have been recognized in about 90 boreholes grouped mostly in the Koszalin — Chojnice area and along the Baltic coast west of Koszalin. More than 50 borehole sections have been investigated to document the stratigraphy and facies distribution within the Upper Devonian and lowermost Carboniferous strata from the Frasnian to the lower Tournaisian (*see* Text-fig. 1). The core samples together with archival data were rendered accessible by the Polish Oil and Gas Enterprise at Piła and the State Geological Survey in Warsaw.

The presence of the Upper Devonian deposits in northwestern Poland have been discovered relatively lately by TOKARSKI (1959). The results of biostratigraphic investigations of Upper Devonian strata were published during the sixties and seventies and they are scattered in numerous papers concerning either single sections or, most often, a specific fossil group (ŁOBANOWSKI 1968, 1969; STASIŃSKA 1969; NEHRING 1971; KOREJWO 1975; MATYJA 1972, 1974, 1975a, b, 1976; TURNAU 1975, 1979). These introductionary biostratigraphic conclusions, however, were unsatisfactory, because they were only of regional importance. Moreover, little attention was paid to aspects of the

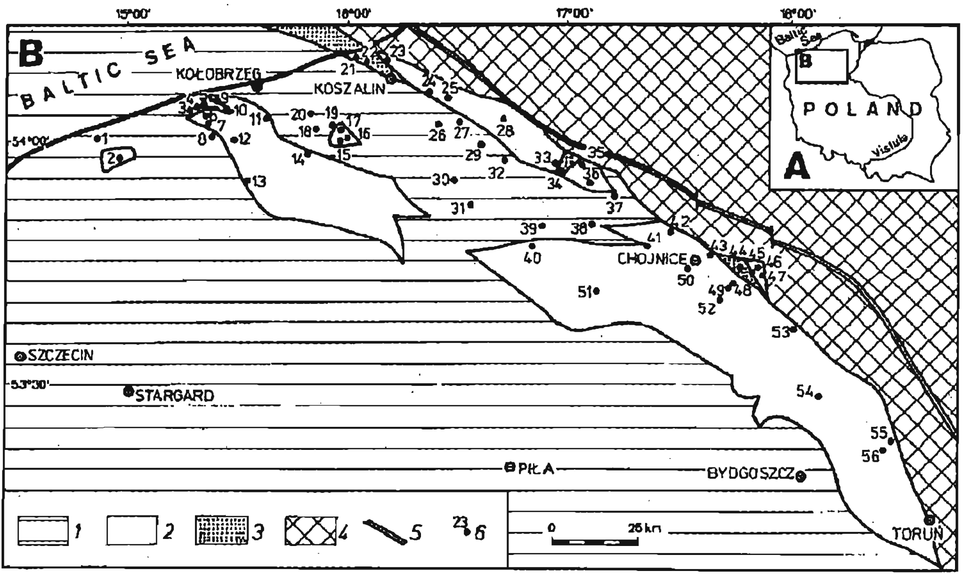


Fig. 1. Sub-Permian map of Western Pomerania and Kujawy regions in northwestern Poland, to show the distribution of Devonian and Carboniferous deposits and the location of studied boreholes [B] (*adopted from* POŻARYSKI & DEMBOWSKI 1984, *and* POŻARYSKI 1987); inset [A] shows the position of the area in Poland

1 — Carboniferous, 2 — Upper Devonian, 3 — Middle Devonian, 4 — Silurian and Ordovician, 5 — Teisseyre-Tornquist tectonic line (*after* ZNOSKO 1969, 1975; POŻARYSKI 1987), 6 — numbers of boreholes, as given below

1 — Strzeżewo *1*, 2 — Świerzno *4*, 3 — Trzebusz *1*, 4 — Gorzysław *8*, 5 — Gorzysław *9*, 6 — Gorzysław *14*, 7 — Gorzysław *11*, 8 — Gosław *1*, 9 — Karcino *1*, 10 — Karcino *2*, 11 — Gościno *IG-1*, 12 — Białokury 2, 13 — Rymań 2, 14 — Zagórze *1*, 15 — Białogard *9*, 16 — Białogard *8*, 17 — Białogard *3*, 18 — Karlino *1*, 19 — Daszewo *3*, 20 — Daszewo *12*, 21 — Jamno *IG-3*, 22 — Jamno *IG-2*, 23 — Jamno *IG-1*, 24 — Wyszebórz *1*, 25 — Kościernica *1*, 26 — Kłanino *1*, 27 — Karsina *1*, 28 — Polanów *2*, 29 — Gozd *2*, 30 — Chmielno *1*, 31 — Wierzchowo *4*, 32 — Drzewiany *1*, 33 — Miastko *1*, 34 — Miastko *2*, 35 — Miastko *3*, 36 — Koczała *1*, 37 — Brda *1*, 38 — Rzeczenica *1*, 39 — Bielica *1*, 40 — Bielica *2*, 41 — Człuchów *IG-1*, 42 — Babilon *1*, 43 — Krojanty *1*, 44 — Nicponie *1*, 45 — Stobno *2*, 46 — Stobno *3*, 47 — Chojnice *3*, 48 — Chojnice *2*, 49 — Chojnice *5*, 50 — Chojnice *4*, 51 — Debrzno *IG-1*, 52 — Tuchola *IG-1*, 53 — Bysław *2*, 54 — Wudzyń 1, 55 — Unisław *2*, 56 — Unisław *IG-1*

Upper Devonian succession other than biostratigraphy, particularly lithofacies details and their interpretation, although the depositional pattern was generally outlined by PAJCHLOWA (1964, 1968) and PAJCHLOWA & MIŁACZEWSKI (1974).

The first attempt to present the pattern of Devonian and Carboniferous lithological bodies was that by R. DADLEZ (1978). ŻELICHOWSKI (1983, 1987) revised DADLEZ' lithostratigraphic division of the Carboniferous and presented a synthesis of stratigraphic data which have been published subsequently.

During the last decade progress has been made in Western Pomerania due to the study of microfossils as well as microfacies analysis. Several biostratigraphic contributions (*i.e.* ŻBIKOWSKA 1983, 1992; NOWIŃSKI & PREJBISZ 1986; MATYJA & TURNAU 1989; CLAYTON & TURNAU 1990) as well as some comprehensive studies were performed (MATYJA 1987, 1988; MATYJA & NARKIEWICZ 1992b).

A full treatment of the Late Devonian geologic history of Western Pomerania, controlled by conodont-based biostratigraphy, is herein presented for the first time. Several informal lithostratigraphic units of the formation or member rank have been distinguished. Biostratigraphic analyses based mainly on Author's own published and unpublished data on conodonts enabled the units to be dated and intercorrelated. However, data on miospores by TURNAU (1978, 1979) as well as on entomozoacean ostracodes by ŻBIKOWSKA (1986, 1992) have also been used.

The litho- and biofacies analysis of Upper Devonian sequences presented below was directed towards finding a common pattern at least on the scale of the epicratonic Pomeranian sea. Turning points in the Pomeranian sedimentary area were than compared with the published descriptions of Late Devonian events, in particular with the eustatic curve of JOHNSON & *al.* (1985), modified by JOHNSON & SANDBERG (1989) and SANDBERG & *al.* (1992), to look for potential counterparts of the described events in other parts of the world.

GENERAL STRUCTURAL FRAMEWORK

The area of Poland is cut across by the boundary of the East European Precambrian craton and the Paleozoic platform of central and western Europe. The boundary is formed by the Teisseyre-Tornquist tectonic zone (ZNOSKO 1979; R. DADLEZ 1980, 1982) which is the part of the Tornquist lineament (R. DADLEZ 1990). It represents a set of mainly NW-SE trending dislocations and is characterized by relatively great tectonic autonomy and mobility (ZNOSKO 1986). The facies and thickness patterns of the Devonian and Carboniferous formations indicate that the margin of the Precambrian craton was an important paleogeographic and paleotectonic boundary (R. DADLEZ 1982, 1987, 1990). During Late Carboniferous time block movements resulted in the development of a system of longitudinal and transverse faults and the dissection of the marginal zone of the craton into many blocks. However, it

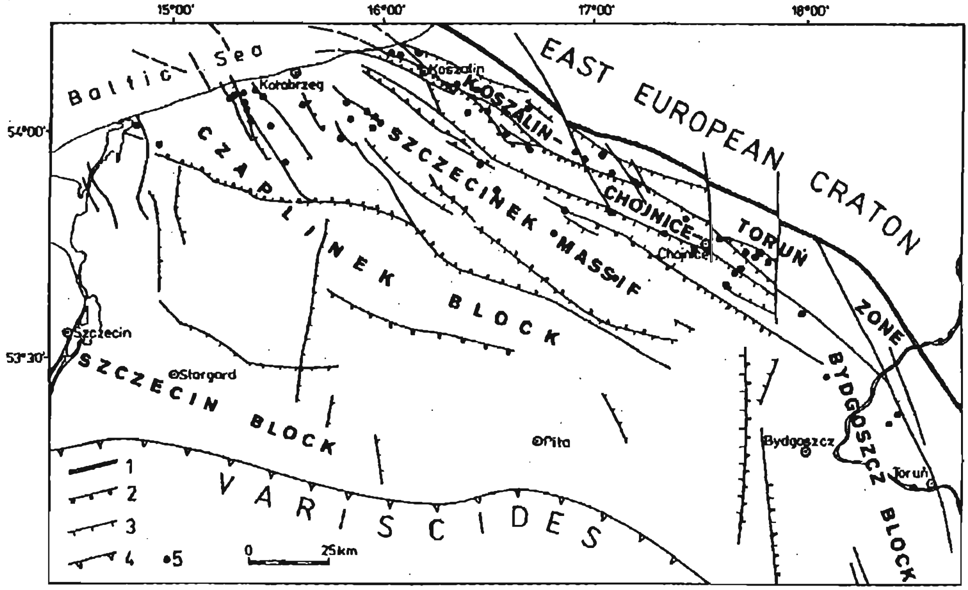


Fig. 2. Tectonic-sketch map of sub-Permian Paleozoic deposits of Western Pomerania and Kujawy regions (simplified *after* Požaryski 1987)

1 — Limit of East European craton, 2 — Caledonian and epi-Caledonian faults, 3 — Variscan and epi-Variscan faults, 4 — outer limit of Variscan orogenic zone; ticks on faults indicate downthrow, 5 — boreholes; *see* Text-fig. 1 for key to their location

seems that some of these faults must have been of earlier origin (R. Dadlez 1978, 1982; Požaryski 1987). It is supposed that during the deposition of the Late Devonian and Early Carboniferous strata, syndepositional faults segmented the Pomerania epicratonic seafloor into several sub-basins. The differential subsidence of these sub-basins controlled the sedimentation within (Požaryski 1975, R. Dadlez 1978). As a result of these differential movements the thickness of the Upper Devonian sediments varies greatly, for instance from only 700 m near Koczała in the northeast to over 2000 m in the Brda — Babilon — Człuchów area (Text-figs 3-4; *see* also Text-fig. 1 for location). The presence of such deep faults in the Paleozoic basement is also indicated by the distribution of carbonate buildups (Matyja 1988).

The present-day northeastward extent of the Devonian and Carboniferous sediments in Western Pomerania (*see* Text-fig. 1) is sharply delineated by the NW-SE striking Koszalin — Chojnice — Toruń tectonic line (*see* Text-fig. 2) corresponding to the margin of the East European Precambrian craton. The preserved fragment of the Devonian-Carboniferous cover is dissected by faults of similar strike (*see* Text-figs 1-2). It is supposed that initially these sediments extended further northwards and eastwards (R. Dadlez 1978, Marek & Znosko 1983).

The present-day pattern of the Devonian and Carboniferous subcrops is the result of the differential mobility of particular tectonic blocks. The pattern of the principal tectonic units is related to the main fault configuration and their activity (POŻARYSKI 1986, 1987).

The Devonian-Carboniferous cover is discontinuous and strongly faulted in the Koszalin — Chojnice — Toruń tectonic zone where intensive block movements at the end of the Carboniferous Period removed part of the Devonian-Carboniferous cover exposing the Middle Devonian deposits situated near the craton edge (*see* Text-fig. 1). The downthrow of the pre-Permian faults is hundreds to thousands meters. The Szczecinek massif delineating the southern boundary of the Koszalin — Chojnice — Toruń zone was relatively weakly faulted (*see* Text-fig. 2). The Czaplinek, Szczecin and Bydgoszcz tectonic blocks are still not well recognized (POŻARYSKI 1986, 1987). There, the Devonian deposits are covered by Carboniferous and younger deposits of a considerable thickness.

LITHOSTRATIGRAPHY

A lithostratigraphic framework for the Upper Devonian strata of Western Pomerania was first proposed by R. DADLEZ (1978), who subdivided the Upper Devonian sediments into several informal units, called "complexes" and "subcomplexes"; this lithostratigraphic division was soonafter supplemented by MIŁACZEWSKI (1979, 1980, 1986, 1987). Nevertheless, insufficient biostratigraphy and lack of broadly termed facies analysis hampered further studies.

Five lithostratigraphic units informally called "formations", and four units called "members", have been distinguished here. The informal status of these units is due to the fact that the material investigated does not fulfil the requirements for establishing the new stratotypes (*see* ALEXANDROWICZ & *al.* 1975). Some of them were newly introduced and some are partly consistent with those distinguished previously. However, the new definitions have been proposed after extensive analysis of data from more than 50 borehole sections (*see* Text-figs 3-4). The lower and upper limits of the lithostratigraphic units have been established mostly by means of geophysical data. These units in ascending order, are:

(*i*) The Koczała Formation, which is the Koczała complex *sensu* R. DADLEZ (1978), together with the Stobno complex *sensu* R. DADLEZ (1978);

(*ii*) The Człuchów Formation, which is a part of the Człuchów complex *sensu* R. DADLEZ (1978), *i.e.* the lower marly, intermediate and part of the limestone subcomplex, divided in this paper into the Strzeżewo, Gorzysław, Gościno, and Bielica members;

(*iii*) The Krojanty Formation, which is a part of the limestone subcomplex of the Człuchów complex *sensu* R. DADLEZ (1978);

(*iv*) The Kłanino Formation, which is the Kłanino complex *sensu* R. DADLEZ (1978);

(*v*) The Sąpolno Formation, which is the uppermost part of the Człuchów complex *sensu* R. DADLEZ (1978), *i.e.* the upper marly subcomplex, together with the Sąpolno complex of ŻELICHOWSKI (1983).

The petrographic details presented below are based mainly on Author's own material (hundreds of thin sections) as well as on the papers by J. DADLEZ (1975, 1976, 1977) and J. DADLEZ & R. DADLEZ (1986).

THE KOCZAŁA FORMATION

The Koczała Formation is characterized by the presence of stromatoporoid-coral limestones, with thin sandstones and mudstones intercalations, typical for the lower part of the formation.

The Koczała Formation is underlying both by the Wyszebórz and Chojnice formations. The Wyszebórz Formation consists of gray fine-grained dolomitic sandstones and mudstones, in the northwest the formation also contains conglomerates in which quartz pebbles are the dominant components (R. DADLEZ 1978). The uppermost part of the formation consists of sandstones and thin intercalations of dolomitic mudstones with a marine fauna. The Chojnice Formation consists of light-gray, fine-grained, poorly sorted sandstones interbedded with marly shales and marls containing ostracodes and tentaculitids. In the upper part of the Chojnice Formation two lithologic types dominate in the Unisław *IG-1* section: (*i*) light gray, fine-grained and non-calcareous quartz sandstones with abundant lithoclasts and plant detritus, and (*ii*) gray or gray green non-calcareous mudstones and shales with vertical or subvertical burrowing traces, plant detritus, occasionally with fish teeth and scales (J. DADLEZ & R. DADLEZ 1986). Both these lithofacies are often arranged in the fining-upward cycles. Erosional surfaces are also present. Thick sandy deposits disappear in the upper, Late Devonian, parts of the Wyszebórz and Chojnice formations, and shales as well as carbonates become dominant.

The Koczała Formation occurs in the Koszalin — Chojnice — Toruń area, where it overlies the Wyszebórz Formation in the Koszalin — Koczała area (in the Jamno *IG-1*, Wyszebórz-*1*, Kościernica-*1*, Polanów-*2*, Miastko-*1*, Miastko-*3* and Koczała-*1* sections), as well as in the Stobno area (in the Stobno-*3* and Chojnice-*3* sections) and the Chojnice Formation in the Unisław area (in the Unisław *IG-1* and Unisław-*2* sections). In the Kołobrzeg region (the Strzeżewo — Gorzysław — Gościno area) the Wyszebórz Formation is overlain by the Strzeżewo Member, the oldest unit of the Człuchów Formation, whereas in the Człuchów — Chojnice area (the Człuchów *IG-1*, Chojnice-*5* and Tuchola *IG-1* sections) the Strzeżewo Member overlies the Chojnice Formation (*see* Text-figs 3-4 and 8). This apparently chaotic lateral distribution of the Upper Devonian formations is closely related to the position of the East European craton margin. The Koczała Formation is, therefore, connected with the shallow facies belt close to the craton, whilst the Strzeżewo Member characterizes a deeper facies belt, located generally SW of the craton.

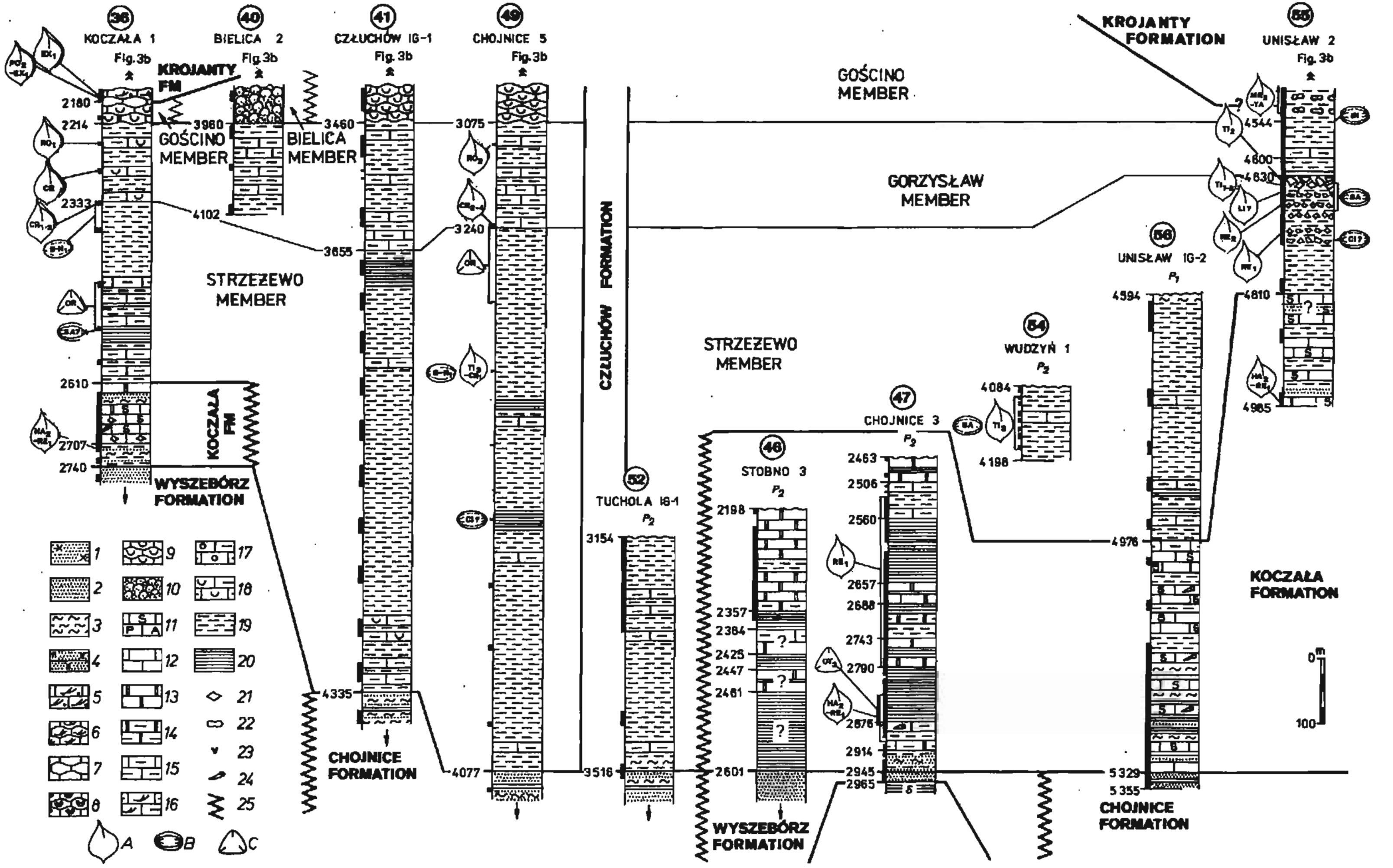
General lithologic and stratigraphic studies of the Koczała Formation are those by NEHRING (1971), J. DADLEZ (1976), J. DADLEZ & R. DADLEZ (1986), R. DADLEZ (1978), and NOWIŃSKI & PREJBISZ (1986). Due to these studies it is possible to distinguish several lithologic types within the Koczała Formation (*see* Pls 1-2).The first three varieties are typical for the lower part, the last two for the upper part of the formation;

(1) Quartz sandstones, subordinately calcareous mudstones, sometimes strongly bioturbated and containing unidentifiable bioclasts. In general, the Koczała sandstones are calcareous, more mature and better sorted than those of the underlying Wyszebórz and Chojnice formations;

(2) Dark-gray marly mudstones and shales with rare bivalves, inarticulate brachiopods, and ostracodes;

(3) Dark-gray marly limestones with common crinoid remains and articulate brachiopod fragments. Subordinate inarticulate brachiopods, bivalves, ostracodes, algae, fish scales and teeth are also noted;

Correlation of the Upper Devonian sections between Chmielno and Unislaw (points No. 30 and 56 *in* Text-fig. 1)



Heavy lines indicate formation boundaries; light lines — member boundaries; wavy lines — erosional surfaces; thick vertical lines on the left side of each section indicate the cored intervals; arrows below and above sections mean that only a part of the given formation is shown

LITHOFACIES COMPONENTS:

1 — Arcosic and graywacke sandstone, 2 — fine-grained quartz sandstone, 3 — mudstone, 4 — dolomitic sandstone, 5 — algal-foraminiferal-peloidal grainstone, 6 — nodular algal-foraminiferal-crinoid packstone/grainstone, 7 — nodular algal-foraminiferal-crinoid wackestone to packstone, 8 — nodular crinoid-brachiopod-bryozoan packstone/grainstone, 9 — nodular crinoid-brachiopod-bryozoan wackestone to packstone, 10 — massive micritic limestone, 11 — stromatoporoid-coral wackestone to packstone (S — massive stromatoporoids, A — *Amphipora*, P — *Phillipsastraea*), 12 — lime mudstone with thrombolite-fenestral structure, 13 — dolomite, 14 — marly dolomite, 15 — marly limestone, 16 — marly algal wackestone to packstone, 17 — marly oolitic limestone, 18 — marly brachiopod-crinoid wackestone, 19 — marl, 20 — marly shale, 21 — conglomerate, 22 — limestone nodules, 23 — anhydrite nodules and/or layers, 24 — solitary corals, 25 — facies interfingering

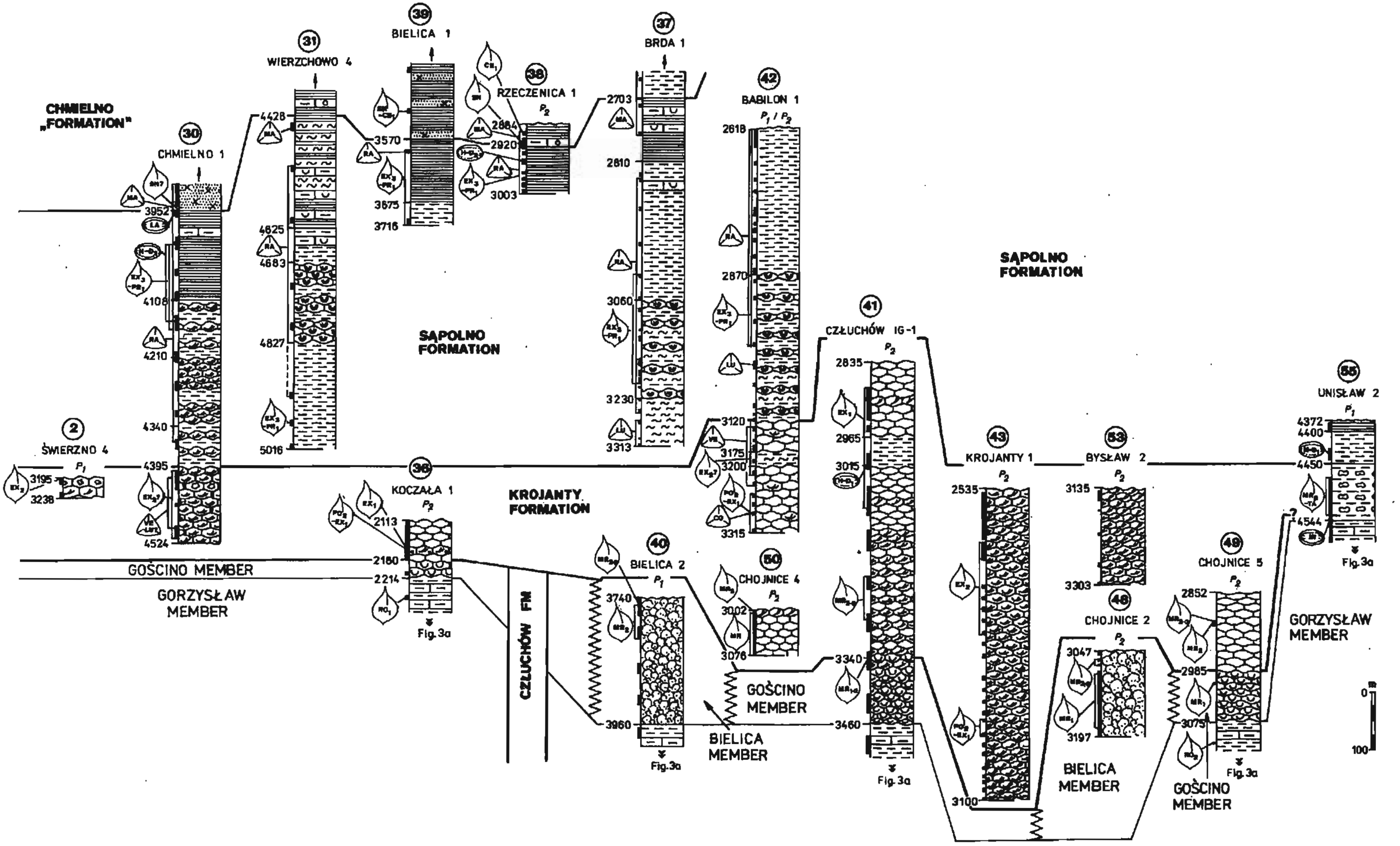
STRATIGRAPHIC BIOZONATION:

A — **Conodont zones:** PU — *punctata*, HA — *hassi* (HA$_2$ — Upper), RE — *rhenana* (RE$_1$ — Lower, RE$_2$ — Upper), LI — *linguiformis*, TI — *triangularis* (TI$_1$ — Lower, TI$_2$ — Middle, TI$_3$ — Upper), CR — *crepida* (CR$_1$ — Lower, CR$_2$ — Middle, CR$_3$ — Upper, CR$_4$ — Uppermost), RO — *rhomboidea* (RO$_1$ — Lower, RO$_2$ — Upper), MR — *marginifera* (MR$_1$ — Lower, MR$_2$ — Upper, MR$_3$ — Uppermost), TA — *trachytera*, PO — *postera* (PO$_2$ — Upper), EX — *expansa* (EX$_1$ — Lower, EX$_2$ — Middle, EX$_3$ — Upper), PR — *praesulcata* (PR$_1$ — Lower), SU — *sulcata*, SN — *sandbergi*, CE — *crenulata* (CE$_1$ — Lower), TY — *typicus*

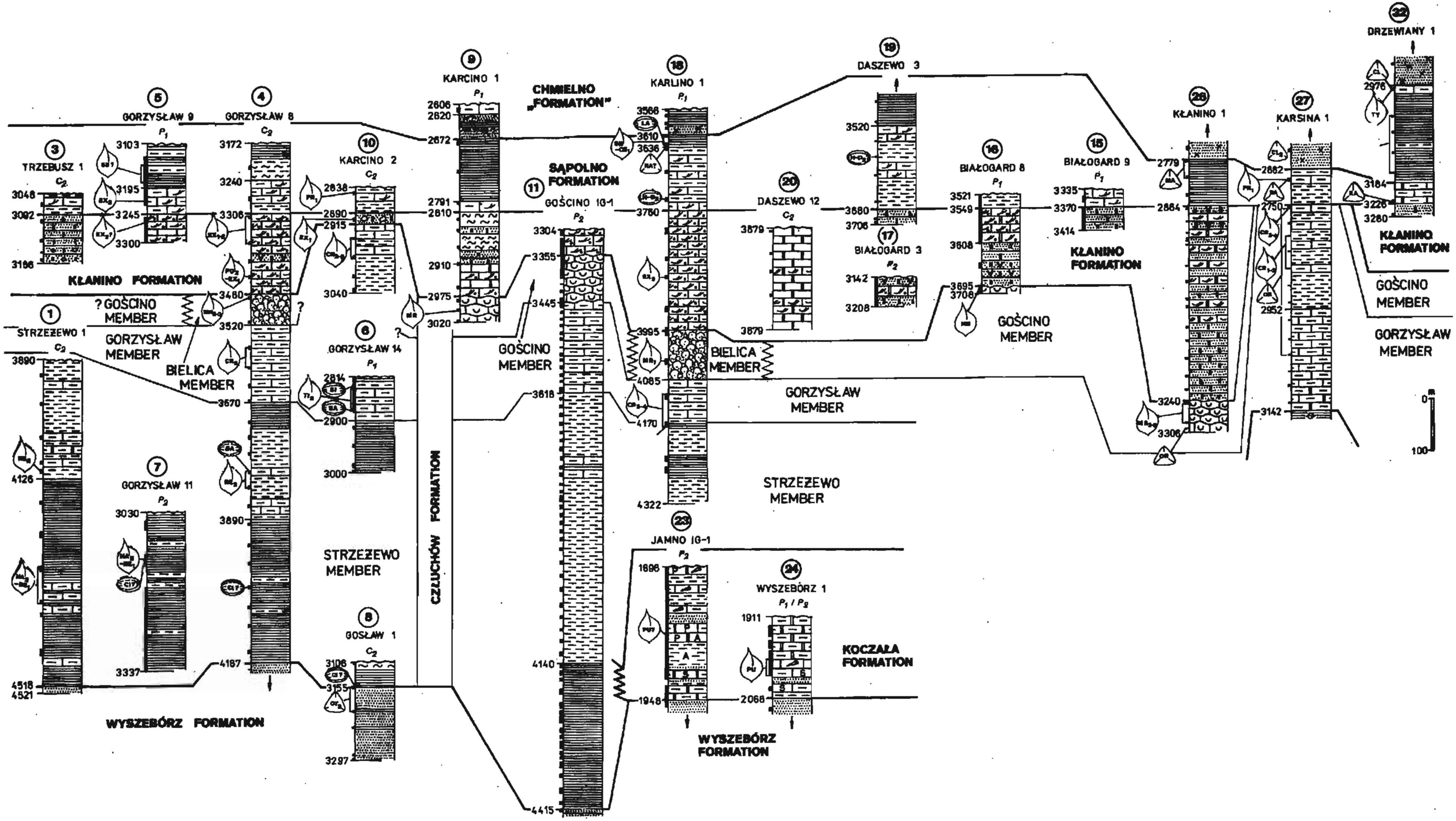
B — **Entomozoacean zones:** CI — *cicatricosa*, SA — *sartenaeri*, SI — *sigmoidale*, S-N — *serratostriata-nehdensis* (S-N$_1$ — Lower), IN — *intercostata*, H-D — *hemisphaerica-dichotoma* (H-D$_1$ — Lower, H-D$_2$ — Upper), LA — *latior*

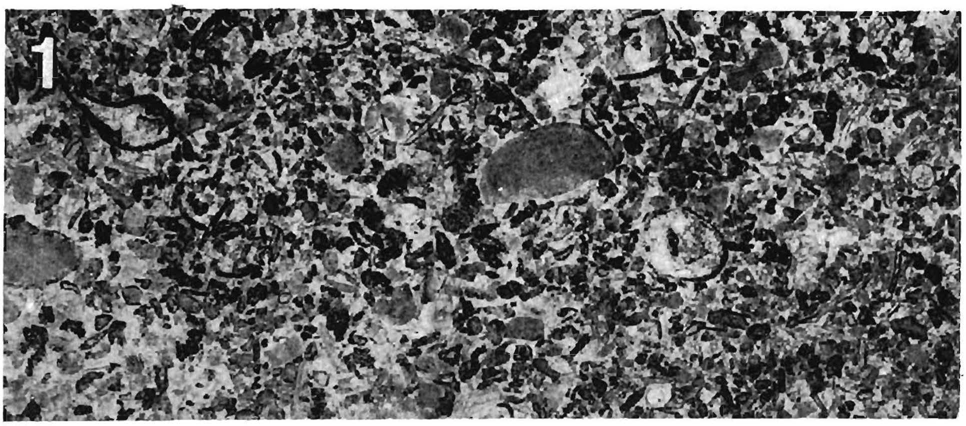
C — **Palynological zones:** OR — *Perotriletes ordinarius*, CO — *Grandispora cornuta*, VE — *Rugospora versabilis*, LU — *Grandispora lupata*, RA — *Tumulispora rarituberculata*, MA — *Convolutispora major*, CL — *Prolycospora claytonii* (CL$_1$ — Lower, CL$_2$ — Middle)

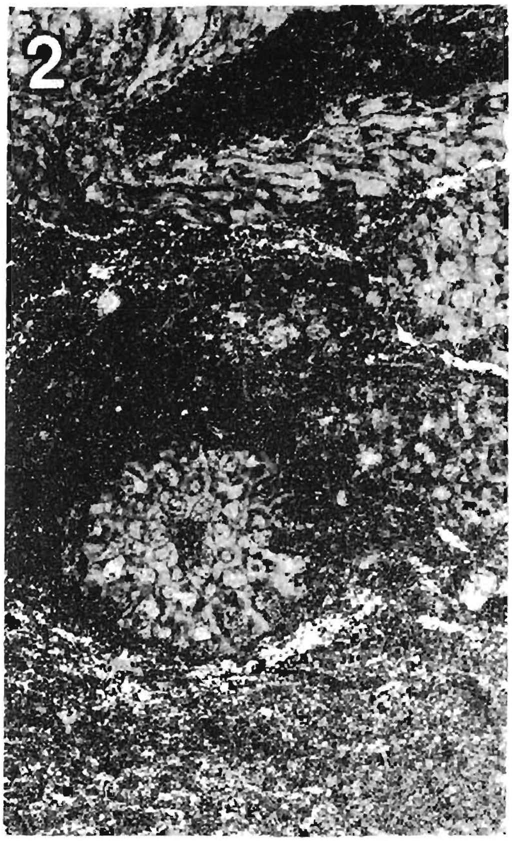
Correlation of the Upper Devonian sections between Chmielno and Unisław (points No. 30 and 56 *in* Text-fig. 1); *see* Text-fig. 3*A* for key to explanations

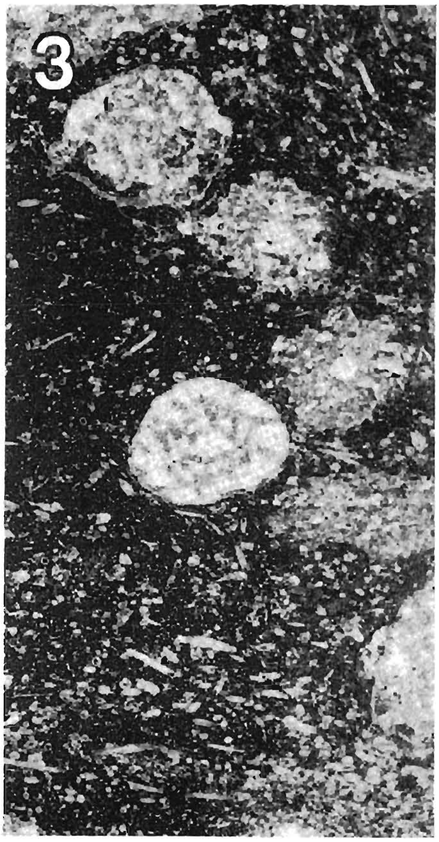


Correlation of the Upper Devonian sections between Trzebusz and Drzewiany (points No. 3 and 32 *in* Text-fig. 1); *see* Text-fig. 3*A* for key to explanations





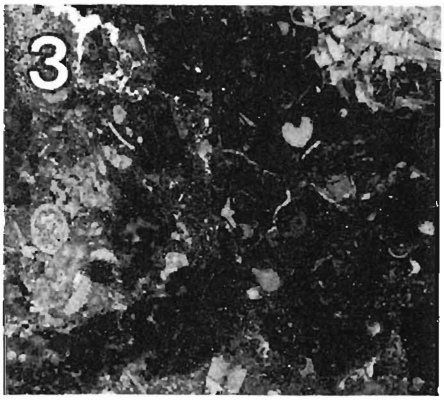


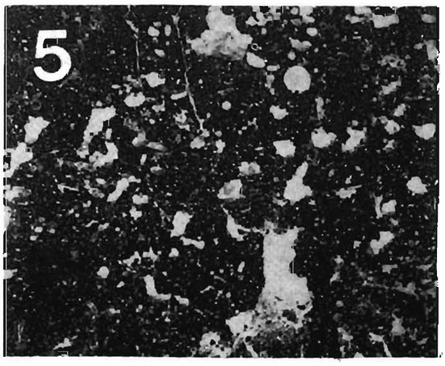


Stromatoporoid-coral Lithofacies (Koczała Formation)

probably the *punctata* Zone, Frasnian

1 — Crinoid-foraminiferal-algal grainstone; borehole Jamno *IG-1* (depth interval 1875-1881 m), × 7.5
2 — Tabulate coral floatstone with *Alveolitella* sp.; *ibidem* (1829-1830 m), × 7.5
3 — Algal-stromatoporoid floatstone with *Amphipora* sp. and Palaeosiphonocladales algae; *ibidem* (1709-1710 m), × 7.5





Stromatoporoid-coral lithofacies (Koczala Formation)

punctata — Lower *rhenana* Zones, Frasnian

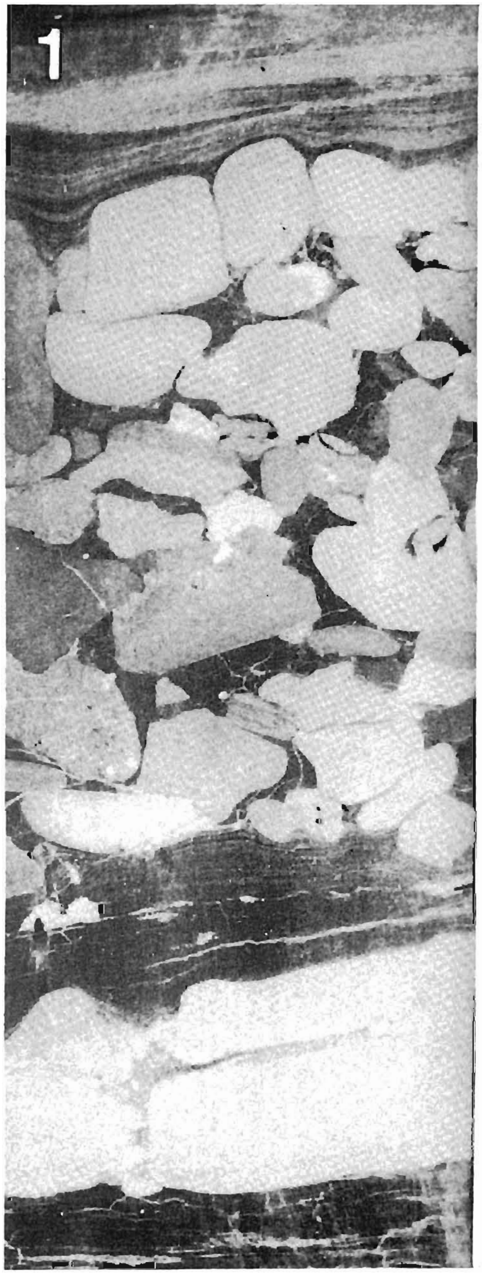
1 — Stromatoporoid-tabulate coral floatstone with *Cladopora* sp.; borehole Unisław *IG-1* (depth interval 5231-5232 m), polished section, nat. size

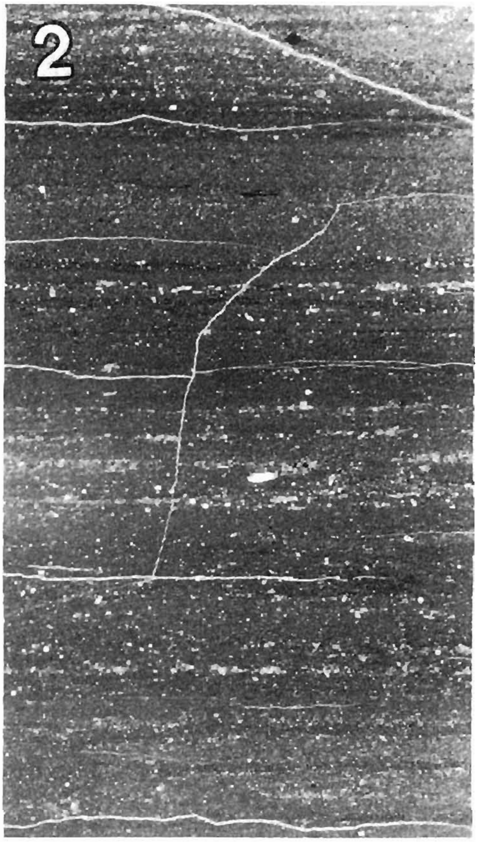
2 — Stromatoporoid floatstone; *ibidem* (5236-5237 m), polished section, nat. size

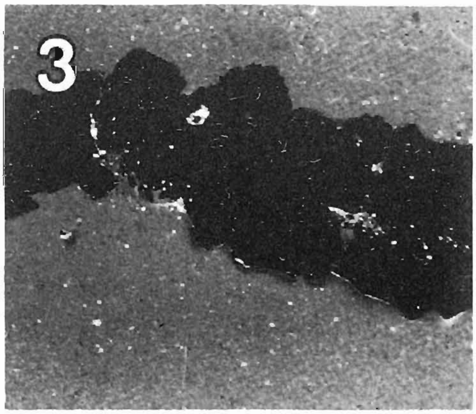
3 — Algal-tabulate coral floatstone with abundant *Renalcis* sp. and *Alveolitella* sp.; Koczała *1* (2675-2675 m), × 4.5

4 — Stromatoporoid-tabulate coral floatstone with *Cladopora* sp.; Unisław *IG-1* (5282-5283 m), polished section, nat. size

5 — Lime mudstone with laminoid-fenestral fabrics; Unisław *2* (4980-4981 m), × 6.7







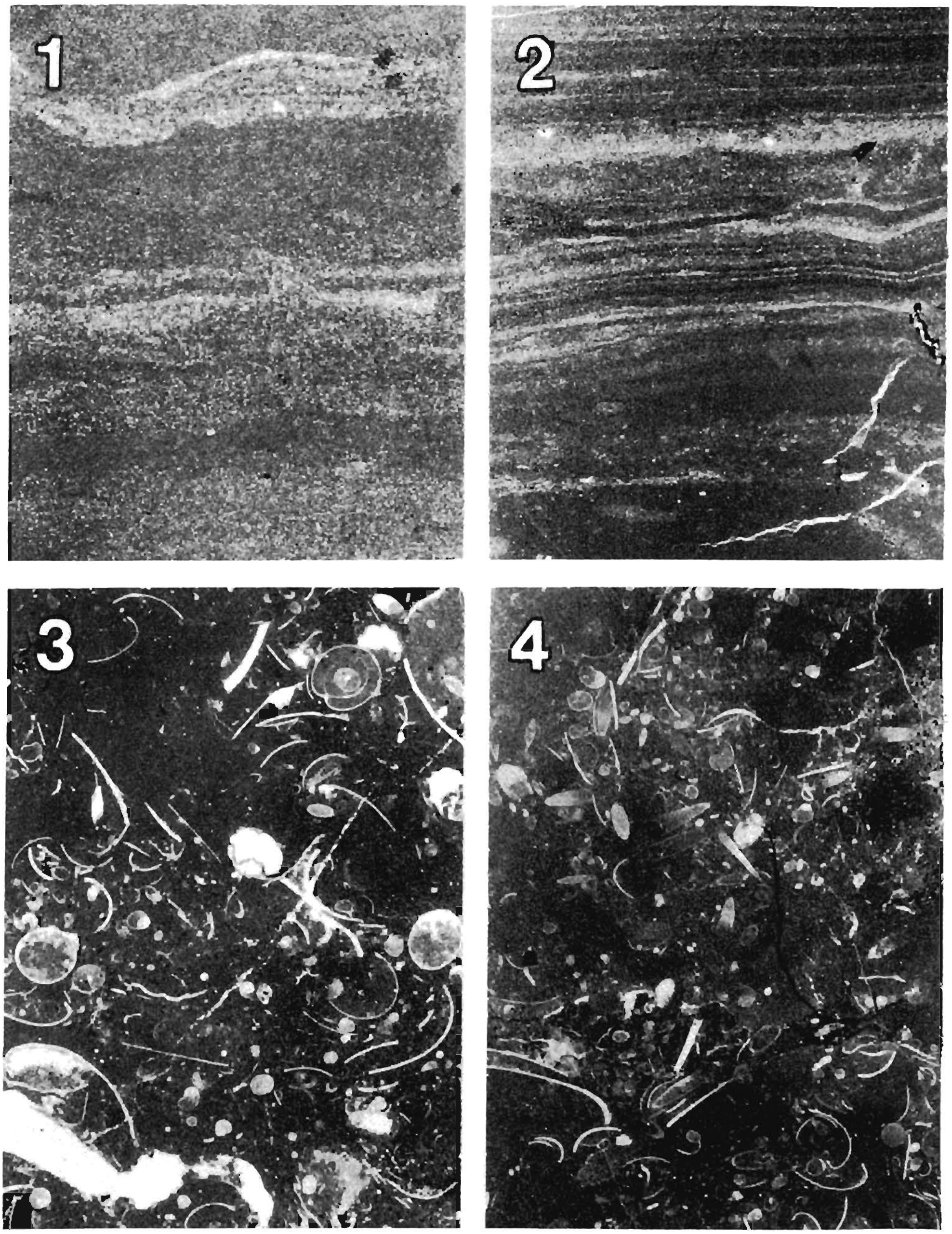
Shale lithofacies (Człuchów Formation, Strzeżewo Member)

Upper *hassi* — Lower *rhenana* Zones, Frasnian (Figs 2-3)
and Lower *triangularis* Zone, Famennian (Fig. 1)

1 — Intraformational conglomerate with clasts of homogenous lime mudstones, peloid grainstones, and lime mudstones with fenestral fabrics; borehole Unisław *2* (depth interval 4644.1-4644.3 m), polished section, nat. size

2 — Marly shale with millimeter-scale lamination; Strzeżewo *1* (4290-4300 m), × 7.5

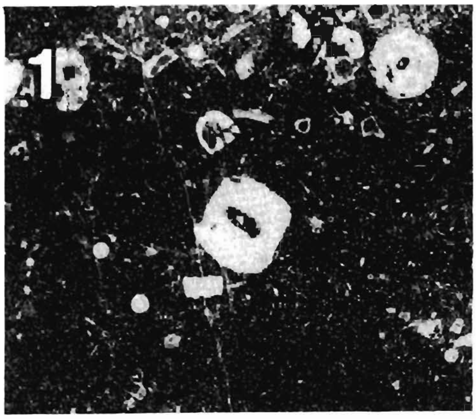
3 — Unfossiliferous marly limestone with pyrite aggregates; *ibidem* (4165-4170 m), × 7.5

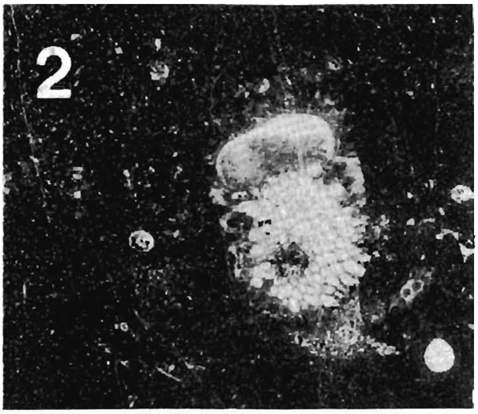


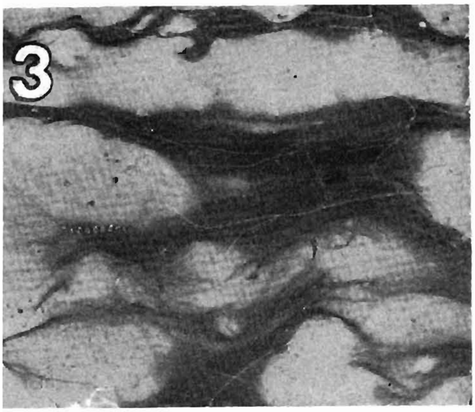
Marly (Figs 1-2) and marly limestone lithofacies (Figs 3-4)
(Człuchów Formation, Gorzysław Member)

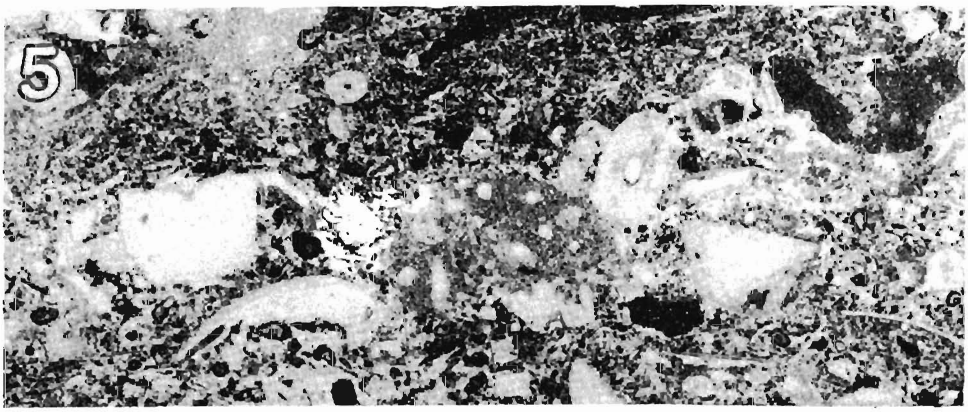
Upper *triangularis* — Upper *rhomboidea* Zones, Famennian

1 — Unfossiliferous laminated marly shale; borehole Człuchów *IG-1* (depth interval 3610-3611 m), × 6
2 — Laminated marly shale with scarce unidentified organic debris; *ibidem* (3496-3497 m), × 4.5
3 — Mollusk wackestone; Gorzysław *14* (2870-2871 m), × 7.5
4 — Tentaculitoid wackestone; *ibidem* (2877-2878 m), × 7.5



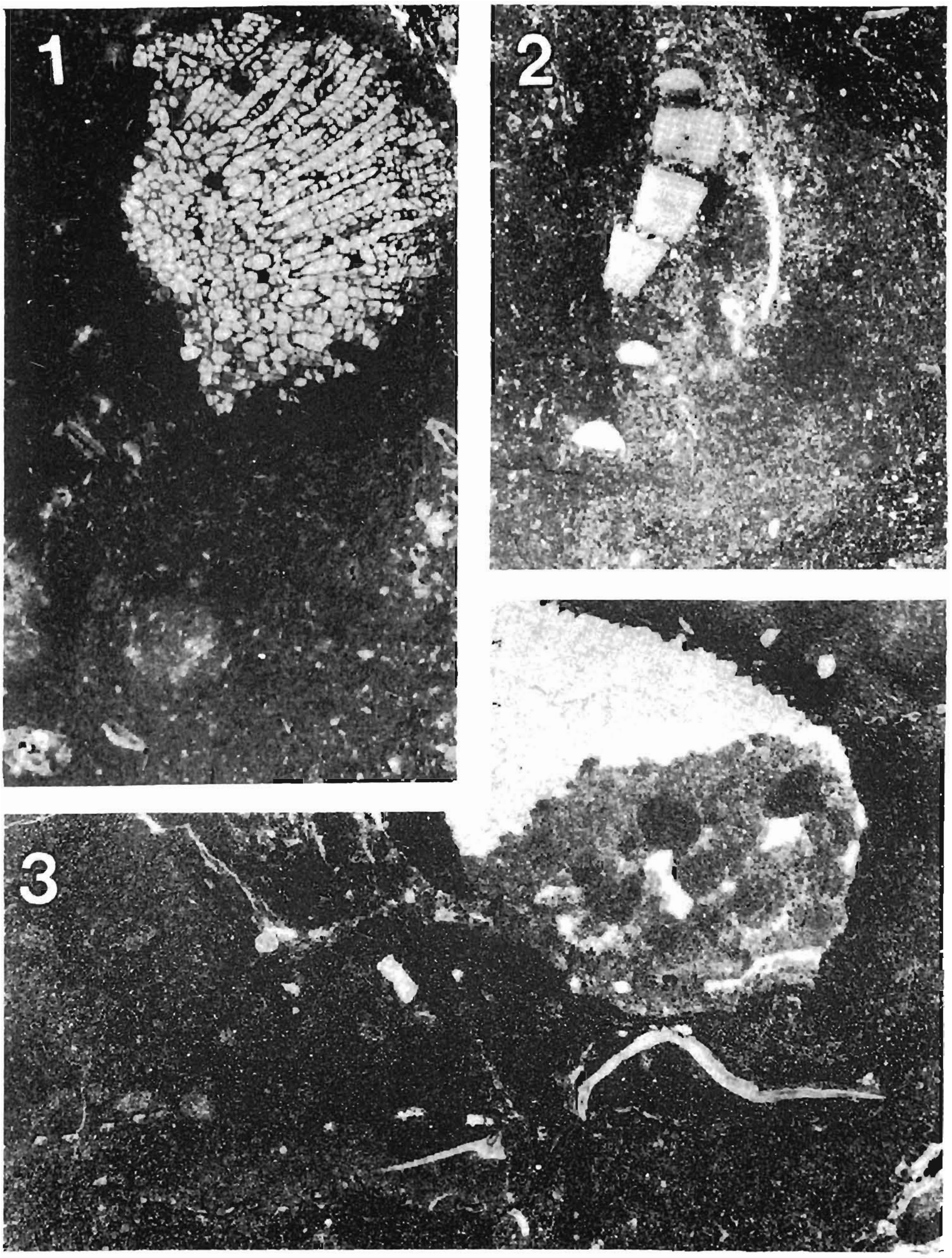






Nodular brachiopod-crinoid lithofacies
(Człuchów Formation, Gościno Member)
Lower — Upper *marginifera* Zones, Famennian

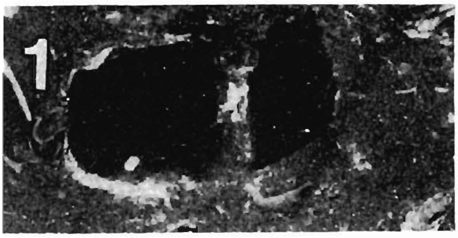
1 — Crinoid wackestone; borehole Człuchów *IG-1* (depth interval 3353-3354 m), × 11.5
2 — Bryozoan-ostracode wackestone; *ibidem* (3360-3361 m), × 11.5
3 — Nodular limestone; *ibidem* (3413-3414 m), polished section, nat. size
4 — Crinoid-brachiopod wackestone to packstone; Białogard *8* (3698-3699 m), × 4.5
5 — Crinoid-brachiopod grainstone; Człuchów *IG-1* (3349-3350 m), × 6

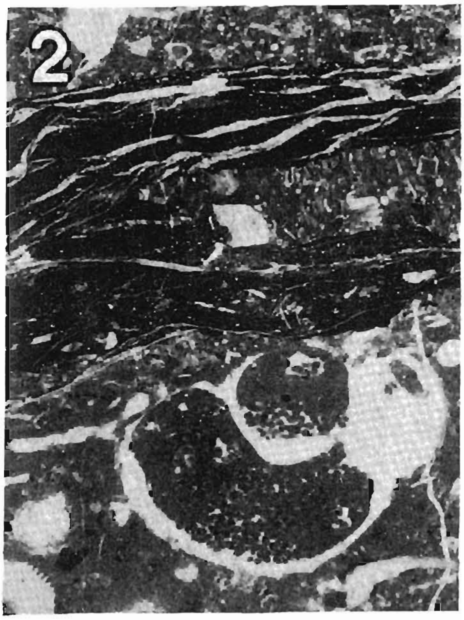


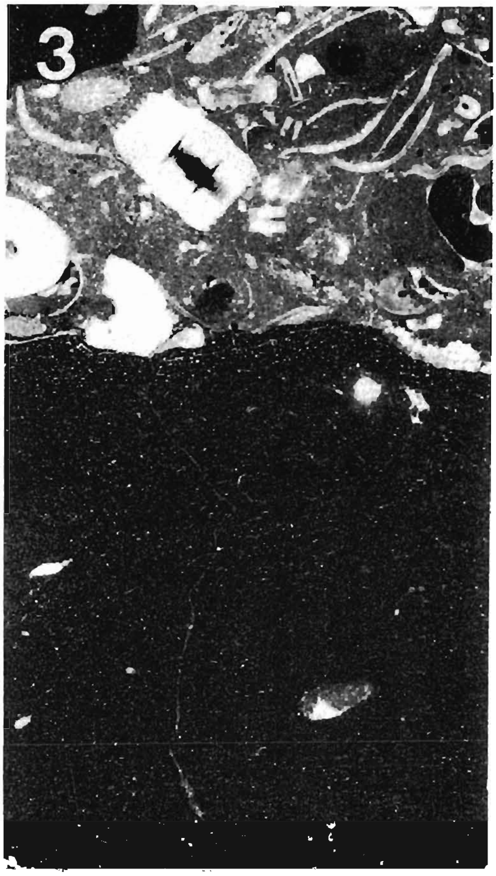
Carbonate buildup lithofacies
(Człuchów Formation, Bielica Member)

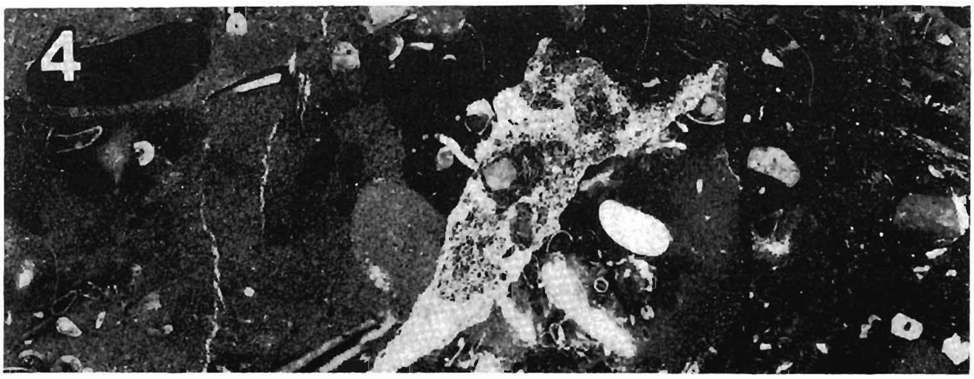
Lower — Upper *marginifera* Zones, Famennian

1 — Crinoid-bryozoan wackestone; borehole Bielica *2* (depth interval 3923-3924 m), × 8.5
2 — Crinoid wackestone; Chojnice *2* (3083-3084 m), × 7.5
3 — Bryozoan bindstone with *Fenestella* sp.; *ibidem* (3106-3107 m), × 7









Carbonate buildup lithofacies (Człuchów Formation, Bielica Member)

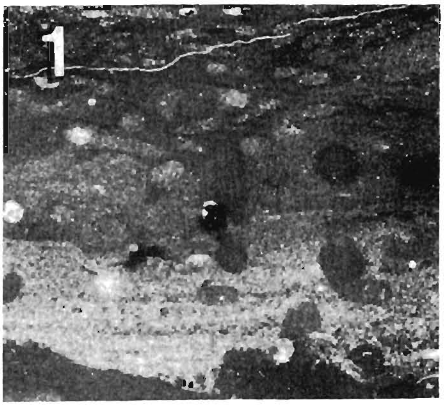
Lower — Upper *marginifera* Zones, Famennian

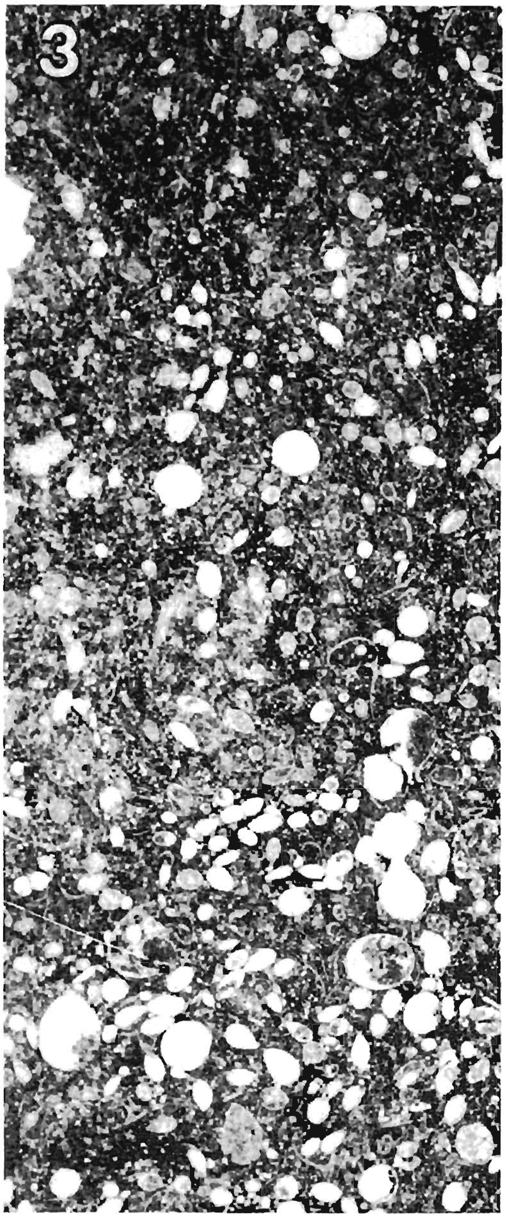
1 — Crinoid-brachiopod-bryozoan wackestone to packstone with lime mudstone intraclast; borehole Chojnice *2* (depth interval 3145-3146 m), × 8

2 — Small-scale fissure filling; at the bottom, normal sediment with gastropods, bryozoans and crinoids; at the top, fissure filled by algal wackestone to packstone; Karlino *1* (3996-3997 m), × 7.5

3 — Contact between lime mudstone and crinoid-brachiopod-bryozoan packstone/grainstone with lime mudstone intraclast; Gorzysław *8* (3471-3472 m), × 6

4 — Intraformational limestone breccia with intraclast of lime mudstone and crinoid-brachiopod wackestone; Karlino *1* (4043-4052 m), × 4.5





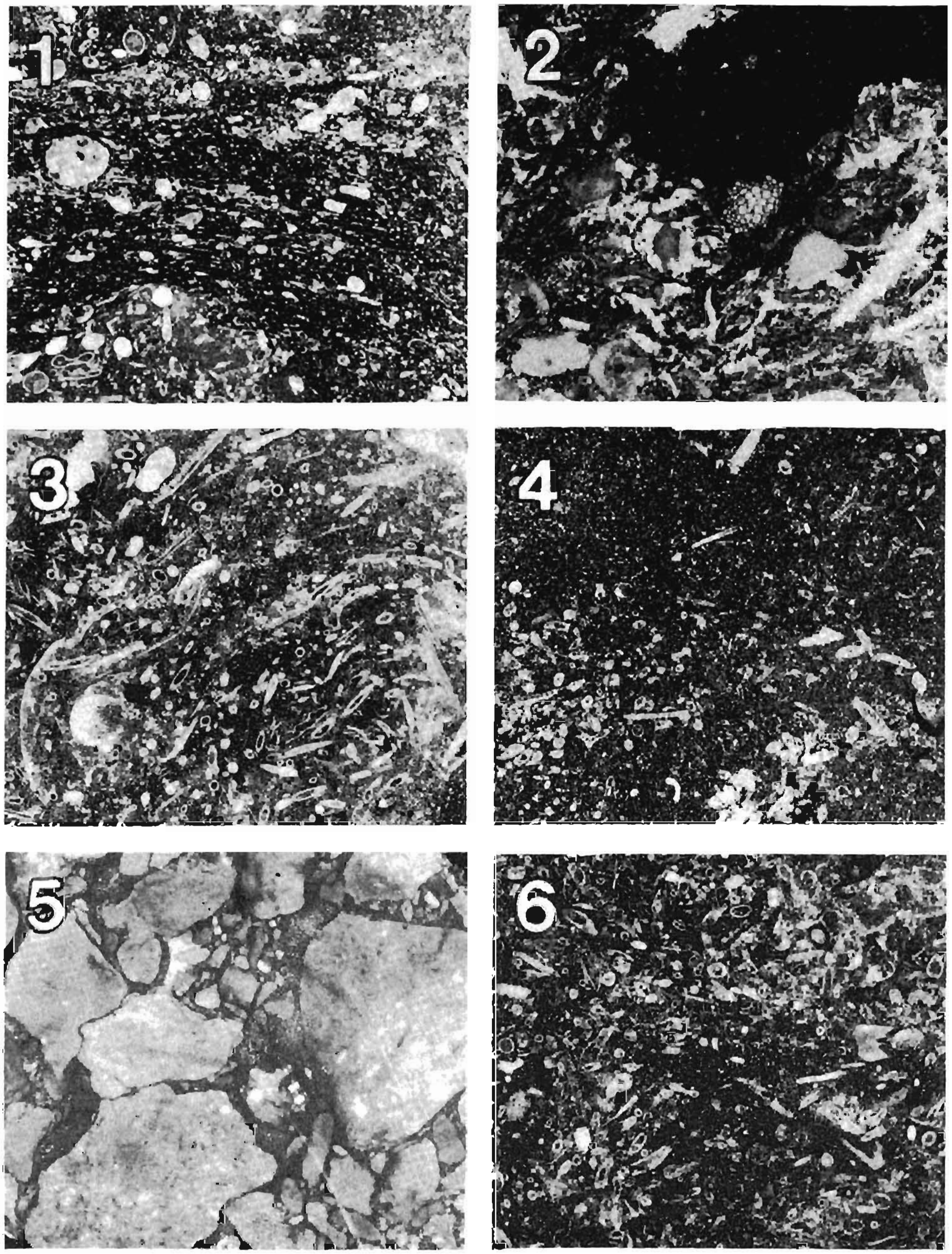
Carbonate buildup lithofacies (Czluchów Formation, Bielica Member)

Lower — Upper *marginifera* Zones, Famennian

1 — Stromatoporoid floatstone with abundant *Amphipora* sp; borehole Chojnice *2* (depth interval 3143-3148 m), × 8

2 — Tabulate coral bafflestone with ?*Multithecopora* sp.; *ibidem* (3095-3096 m), × 2

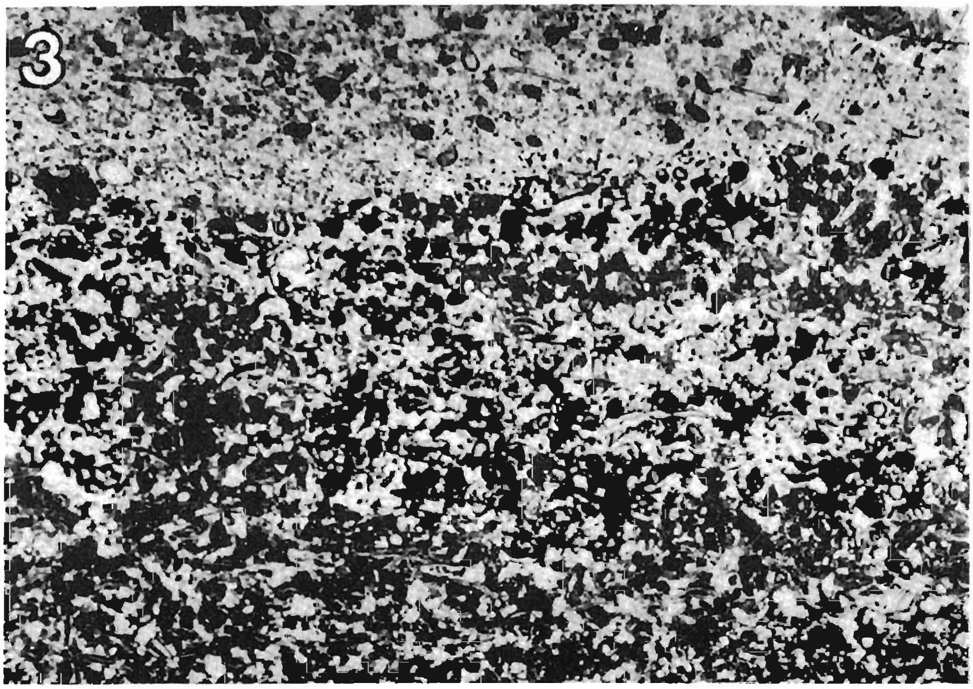
3-4 — Algal floatstone with *Baculella* sp.; Bielica *2* (3769-3771 m), × 4



Carbonate platform lithofacies, algal microfacies (Krojanty Formation)

Lower — Middle *expansa* Zones, Famennian

1 — Algal packstone composed of *Baculella* sp. and Palaeosiphonocladales algae; borehole Człuchów *IG-1* (depth interval 3083-3084 m), × 4.5
2 — Crinoid-brachiopod-bryozoan packstone/grainstone with lime mudstone intraclast; Babilon *1* (3282-3283 m), × 7
3 — Palaeosiphonocladales algal packstone; Człuchów *IG-1* (3073-3074 m), × 7
4 — Palaeosiphonocladales algal wackestone to packstone; Krojanty *1* (2630-2631 m), × 9
5 — Intraformational limestone breccia composed of algal wackestone and packstone intraclasts; Świerzno *4* (3196-3197 m), polished section, nat. size
6 — Palaeosiphonocladales algal floatstone; Krojanty *1* (2668-2669 m), × 11.5



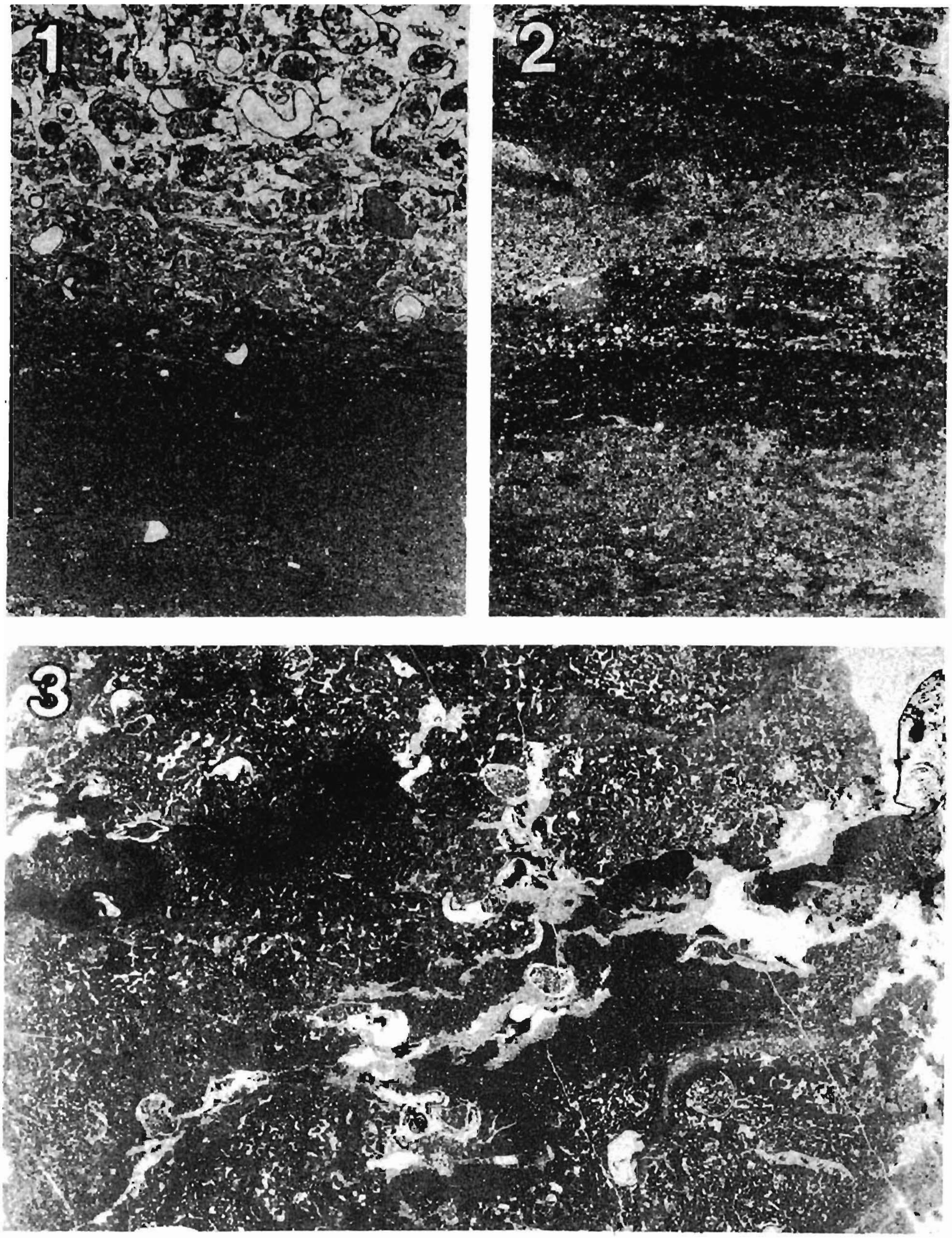
Carbonate platform lithofacies, algal-foraminiferal-peloidal microfacies (Krojanty Formation — Figs 1-2 **and Klanino Formation** — Fig. 3)

Lower *expansa* Zone, Famennian

1 — Algal-foraminiferal grainstone with abundant *Kamaena* sp., fragment of *Solenopora* sp. (right top corner) and intraclast of algal wackestone; borehole Koczała *1* (depth interval 2170-2171 m), × 6

2 — Algal grainstone with lime mudstone intraclasts; *ibidem* (2171-2172 m), × 4.5

3 — Peloidal-bioclastic grainstone with ostracodes, foraminifers and crinoid debris; Gorzysław *8* (3428-3429 m), × 9.5



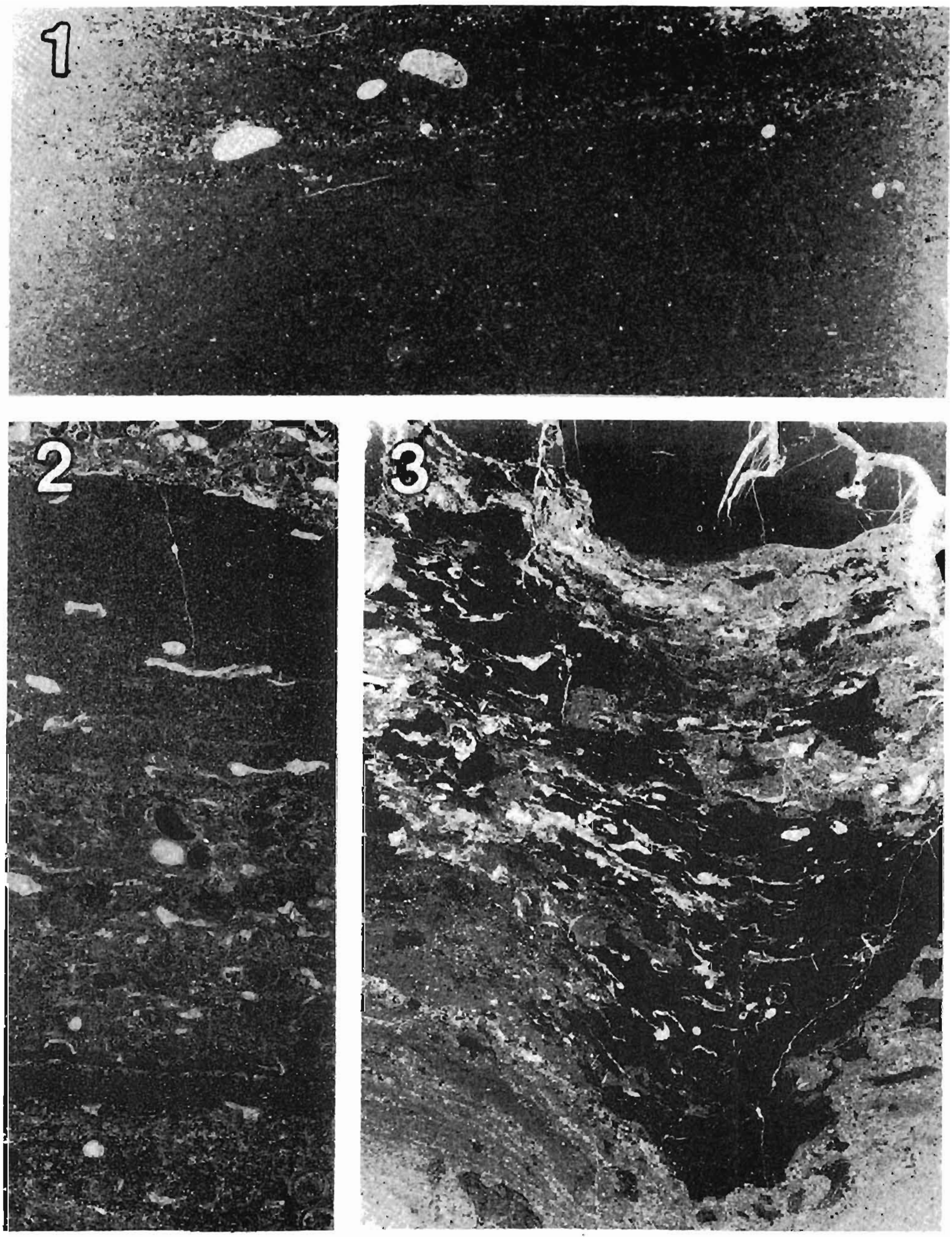
Carbonate platform lithofacies, microbial-laminite — vermiform-gastropod microfacies (Klanino Formation)

Middle *expansa* Zone, Famennian

1 — Microbial-laminite — vermiform-gastropod bindstone; borehole Gorzysław *9* (depth interval 3268.5-3268.8 m), × 6.5

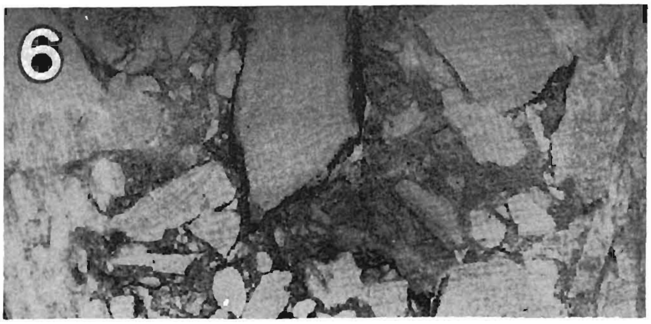
2 — Crypto- to finely crystalline dolostone with fine slightly crenulated lamination; note the presence of crushed vermiform-gastropods between some layers; Karcino *1* (2912-2913 m), × 6.5

3 — Algal-vermiform gastropod bindstone with thrombolite-fenestral structure; Gorzyslaw *9* (3268.3-3268.5 m), × 6.5



Carbonate platform lithofacies,
microbial-laminite — vermiform-gastropod microfacies
(Kłanino Formation)
Middle *expansa* Zone, Famennian

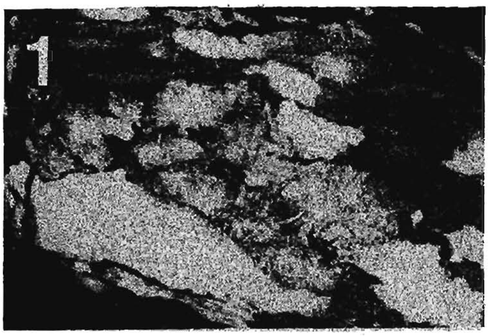
1 — Crypto- to finely crystalline dolostone with fine slightly crenulated lamination and rare vermiform gastropods; borehole Karcino *1* (depth interval 2913-2914 m), × 6
2 — Algal-vermiform gastropod bindstone; Gorzysław *9* (3267.0-3267.5 m), × 4.5
3 — Algal-vermiform gastropod bindstone; *ibidem* (3267.5-3268 m), × 4.5

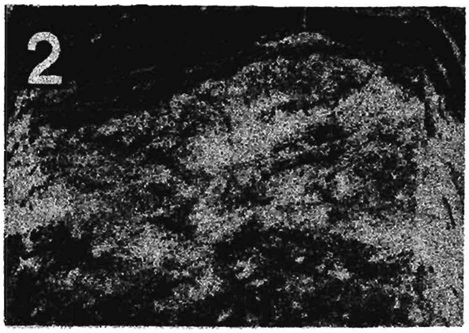


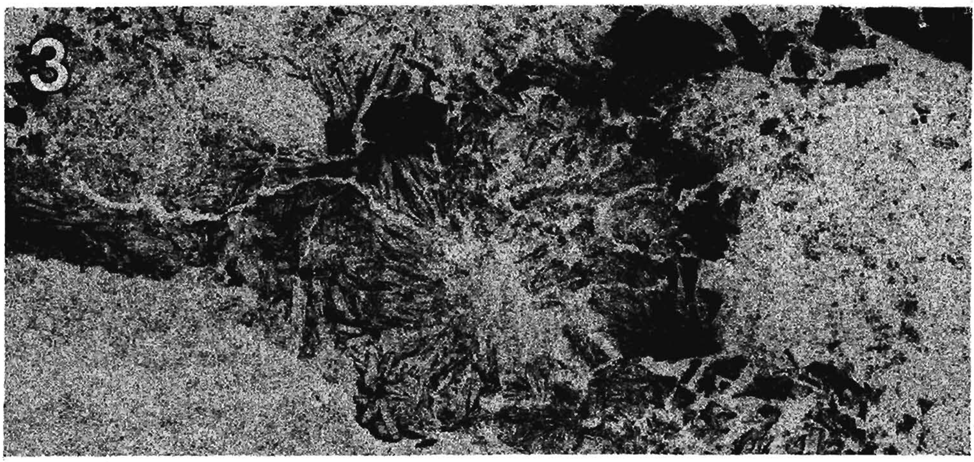
Carbonate-siliciclastic-evaporite lithofacies (Klanino Formation)

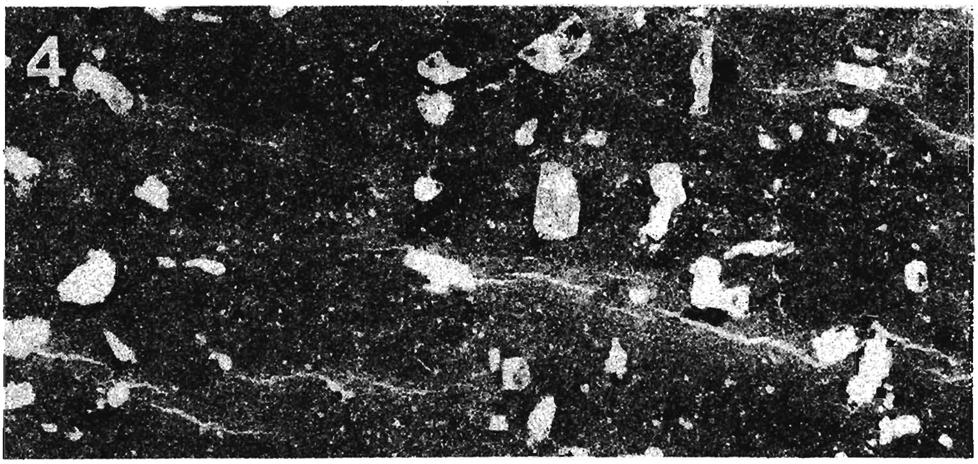
probably Lower — Middle *expansa* Zones, Famennian

1 — Cross-laminated sandstone and siltstone; borehole Klanino *1* (depth interval 3224-3225 m), etched surface, nat. size
2 — Ripple marks in dolomitic sandstone; Bialogard *3* (3147-3148 m), etched surface, nat. size
3 — Ripple marks in dolomitic sandstone; Bialogard *9* (3375-3376 m), polished section, × 0.7
4 — Ripple marks in dolomitic sandstone; Klanino *1* (2944-2945 m), × 4.5
5 — Sandy dolomite with scarce crinoid debris; *ibidem* (2948-2949 m), × 4.5
6 — Intraformational breccia mainly composed of dolomitic sandstone and siltstone clasts; Karcino *2* (2901-2902 m), polished section, nat. size







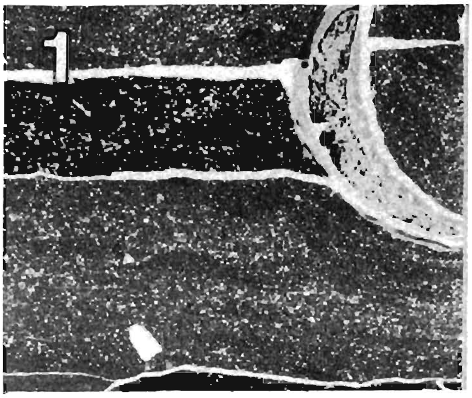


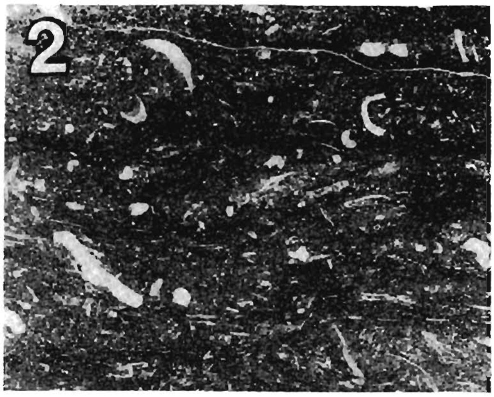
Carbonate-siliciclastic-evaporite lithofacies
(Kłanino Formation)
probably Lower — Middle *expansa* Zones, Famennian

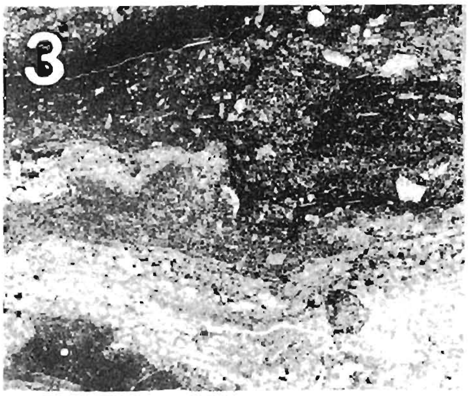
1 — Red dolomitic sandstone with anhydrite occurring as nodules and crystals rosettes (pseudomorphs after gypsum); borehole Białogard 8 (depth interval 3650-3651 m), polished section, nat. size

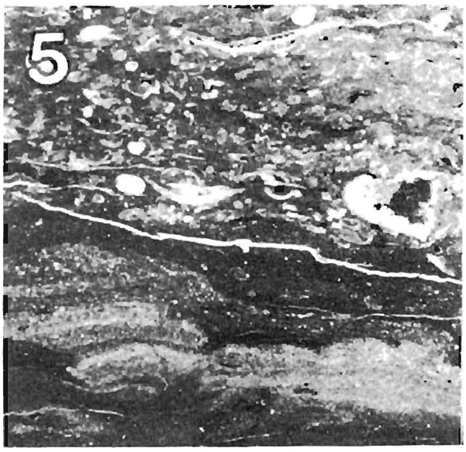
2-3 — Red dolomitic sandstone with white anhydrite occurring as thin beds with a characteristic "chicken-wire" texture, and as crystal rosettes; *ibidem* (3651-3652 m), 2 polished section, nat. size; 3 close-up, × 9

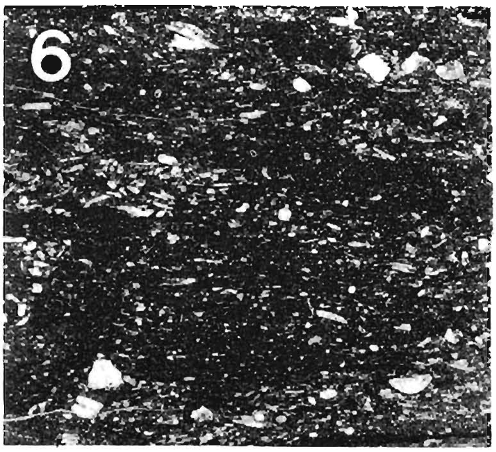
4 — Anhydrite with gypsum crystals (diagenetically silicified); Gorzysław *8* (3396-3397 m), × 6







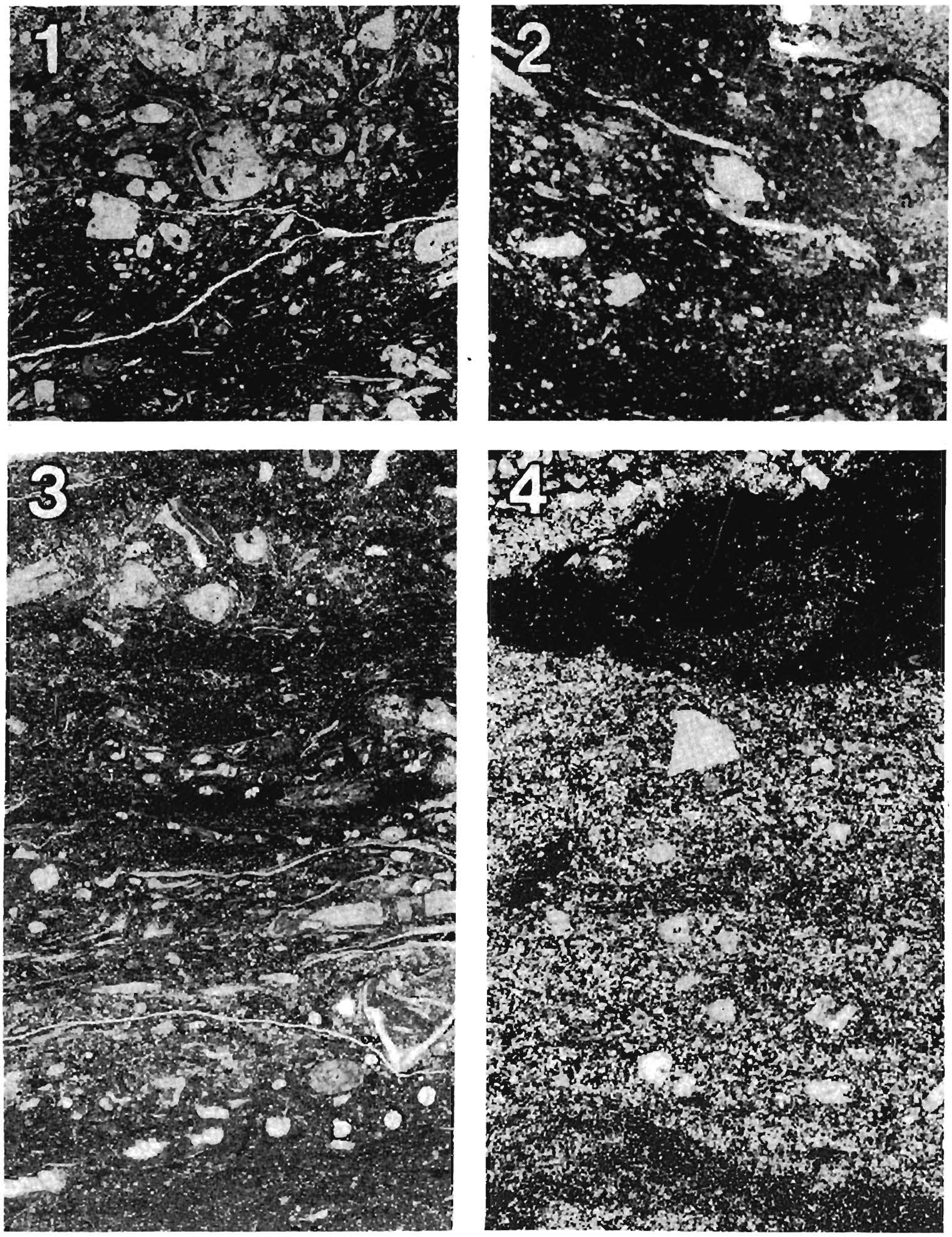




Marly limestone lithofacies (Sąpolno Formation)

Upper *expansa* — Lower *praesulcata* Zones, Famennian

1 — Marly shale containing a complete brachiopod shell; borehole Gorzysław *9* (depth interval 3159-3160 m), × 7.5
2 — Marly bioclastic wackestone with siliciclastic contamination; Karcino *2* (2850-2851 m), × 9
3 — Laminar stromatoporoid bindstone; Białogard *9* (3351-3352 m), × 9
4 — Marly crinoid, brachiopod and agglutinated-foraminifer wackestone; Rzeczenica *1* (2924-2925 m), × 9
5 — Laminar stromatoporoid bindstone; Bielica *1*, (3585-3586 m), × 6.5
6 — Marly agglutinated-foraminifer and crinoid packstone; Białogard *9* (3354-3355 m), × 9



Marly limestone lithofacies (Sąpolno Formation)

Upper *expansa* — Lower *praesulcata* Zones, Famennian

1 — Marly crinoid packstone; borehole Chmielno *1* (depth interval 4140-4141 m), × 4
2 — Marly crinoid-brachiopod packstone; Brda *1* (3196-3201 m), × 8
3 — Bryozoan-crinoid-brachiopod bindstone with *Fenestella* sp.; Babilon *1* (2625-2626 m), × 8
4 — Siltstone with crinoid fragments; Babilon *1* (2621-2622 m), × 8

(4) Stromatoporoid-coral floatstones as well as marly packstones with stromatoporoids and tabulate corals, sparse solitary rugose corals, articulate brachiopods, ostracodes, gastropods, foraminifers, and algae; these organodetrital limestones are considerably differentiated in their allochem composition and grain size. They are usually unsorted and bioclasts vary from arenite to rudite fractions. However, graded detrital limestones and limestones with horizontal grain orientation are also present. Organodetrital limestones are composed mainly of large bioclasts, among which the most frequent are massive stromatoporoid fragments. Intraclasts of micritic limestones and structurless peloids occur subordinately in Unisław *IG-1* and Jamno *IG-1* sections. Two thick detrital intercalations, up to 10 m thick, are unevenly distributed through the Koczała-*1* section. Detrital material predominantly consists of homogenous lime mudstone and algal wackestone intraclasts. The matrix is composed of dark marl with a subordinate admixture of fine-grained detrital quartz;

(5) Light gray, massive or weakly stratified stromatoporoid-coral limestones with some fossils, mainly massive stromatoporoids, preserved in growth position. Some fossils are encrusted with other organisms, which are represented by the problematic alga or foraminifer *Renalcis* (*see* Pl. 2, Fig. 3). Ramose stromatoporoids and corals, never occurring in growth positions, are frequently broken. Massive stromatoporoids, accompanied by corals, are predominant in all localities with some species occurring gregariously. Tabulate assemblages with dendroid colonies (*Thamnopora*, *Alveolitella*) dominate over phaceloid ones (*Syringoporella* and *Sinopora*), and massive tabulates (*Alveolites*) are accompanied by quite numerous dendroid forms (*Amphipora*) and massive stromatoporoids (Nowiński & Przybysz, 1986).

The thickness of the Koczała Formation is only 130 m in the Koczała-*1* section, increasing to 353 m in the Unisław *IG-1* section.

The Koczała Formation consists of two types of mutually overlapping deposits in the Stobno area. These are light gray, usually dolomitized, organodetrital limestones, and black bituminous shales, similar to those of the Strzeżewo Member of the Człuchów Formation. These deposits differ from each other not only in lithology but also in fossil content. Sparse tentaculitoids, bivalves, gastropods and plant detritus characterize the black shales, whilst brachiopods, crinoid fragments and rare solitary corals (*Macgeea* and *Dibunophyllum*) as well as rugose corals (*Phillipsastraea*) occur in dolomitized limestone beds.

The deposits of the Koczała Formation in the Stobno area are of transitional character between the typical carbonate platform deposits of the Koczała Formation and the basin deposits of the Strzeżewo Member.

The preserved fragments of the Koczała Formation deposits in the Stobno area are about 400 m thick in the Stobno-*3* section and 480 m thick in the Chojnice-*3* section.

The basal part of the Koczała Formation is dated as lower Frasnian, probably the *punctata* Zone, whereas the topmost part of the formation belongs to the Lower *rhenana* Zone (*see* Text-figs 3-4 and 8).

THE CZŁUCHÓW FORMATION

The Człuchów Formation consists of a sequence of open-marine shales and carbonates generally displaying a shallowing-upward character.

The formation is herein subdivided into four units, informally called "members" which in ascending order, are: Strzeżewo, Gorzysław, and Gościno Members, the latter of which interfingers with the Bielica Member (*see* Text-fig. 8).

Petrographic details are therein based mainly on Author's own material as well as on the referenced papers (J. Dadlez 1975, 1977).

THE STRZEŻEWO MEMBER

Deposits assigned to the Strzeżewo Member are thin-bedded, and they display monotonous alternation of a few lithological types. The first group of deposits is formed mainly by shales (northern part of the area) and marly shales (eastern part) and subordinately by micritic (more or less marly) limestones (*see* Text-figs 3-4).

Thin beds of black bituminous shales are characterized by millimeter-scale lamination, the presence of pyrite aggregates and rare fossils represented by entomozoacean ostracodes, tentaculitoids and plant detritus (Pl. 3, Figs 2-3). Gray thin-bedded or nodular limestones contain rare cephalopods, tentaculitoids, thin-shelled bivalves (*Buchiola*), lingulids, entomozoacean ostracodes, conodonts, and sometimes articulate brachiopods. Thin beds of gray mudstones as well as fine-grained sandstones are abundant in the lower part of the member.

The second group of the deposits includes detrital limestones. In the Unisław-*2* section the upper part of the formation is developed as shales, marls and marly limestones (often displaying a nodular structure) alternating with intraformational conglomerates (*see* Text-fig. 3*A*). The detrital intercalations are unevenly distributed through the column and range from a few centimeters to about one meter in thickness. Detrital material consists predominantly of homogenous lime mudstone intraclasts with a subordinate admixture of grainy limestones, with clasts usually moderately rounded. The top of the detrital sequence in the Unisław-*2* section contains two beds (0.5 and 1.0 m thick) with unusual, well rounded fragments of carbonate rocks consisting of homogenous lime mudstone clasts, peloid grainstones and lime mudstone clasts with fenestral fabrics (*see* Pl. 3, Fig. 1).

The thickness of the Strzeżewo Member is only 180 m in the Unisław-*2* section, 280 m in the Koczała-*1* section but reaches 837 m in the Chojnice-*5* section.

The base of the Strzeżewo Member is poorly dated but probably belongs to the *punctata* Zone, whereas its top has been determined as belonging to the Middle *triangularis* Zone throughout the area (*see* Text-fig. 8).

THE GORZYSŁAW MEMBER

The Gorzysław Member overlies the Strzeżewo Member throughout Western Pomerania (*see* Text-figs 3-4 and 8). It consists mainly of alternating gray marls (Pl. 4, Figs 1-2) and nodular limestones. Shales are less frequent than in the Strzeżewo Member. An increasing number of benthic organisms, a progressive loss of fine lamination and lighter coloration of rocks up the sections compared with the underlying deposits characterize this member. Nodular limestones often contain crinoid debris, articulate brachiopods, benthic ostracodes, agglutinated foraminifers as well as entomozoacean ostracodes, cephalopods, tentaculitoids and relatively abundant conodonts. Some of the nodular limestones are just rich enough in skeletal remains, to be described as cephalopod and tentaculitoid wackestones (Pl. 4, Figs 3-4).

In the upper parts of some sections even a crinoid-bryozoan wackestone with rare coral debris and chaetetid fragments is observed. Small-scale brecciation, as well as the presence of intraclasts and fine fissure fillings is noted there.

The unit varies in thickness from only 86 m in the Unisław-*2* section, through 120 m in the Koczała-*1* section to about 200 m in the Człuchów *IG-1* section. The Gorzysław Member is overlain by either the Gościno or Bielica members, the last two interfingering each other (*see* Text-fig. 8).

The bottom part of the Gorzysław Member was dated as Middle *triangularis* Zone and its topmost parts is related to the Upper *rhomboidea* Zone in the northern and central part of Western Pomerania but to the Uppermost *marginifera* (or lowermost *trachytera*) Zone in the southern part of the area (*see* Text-fig. 8).

THE GOŚCINO MEMBER

The Gościno Member is known from several boreholes from the northern (Gościno *IG-1*, Daszewo-*12*, Kłanino-*1*, and Koczała-*1*) as well as the southeastern part of Western Pomerania (Człuchów *IG-1*, Chojnice-*5*).

It is characterized by dark gray, rather thick-bedded nodular limestones with a few thin grainstone intercalations (*see* Pl. 5, Figs 3 and 5). Nodules of micritic limestones, a few millimeters to a few centimeters in size, are embedded in a marly matrix. They are lenticular to irregular in shape and contain echinoderm fragments, bryozoans, benthic ostracodes, brachiopods, numerous conodonts and sparse Palaeosiphonocladales algae. Marly crinoid wackestones, marly-bryozoan-ostracode wackestones and crinoid-brachiopod wackestones to packstones prevail in the sequence (*see* Pl. 5, Figs 1-2 and 4). The nodular limestones do not show strong evidence of high depositional energy. The nodules contain well preserved burrows and delicate organic skeletons, whereas the marly matrix displays indications of strong compaction.

Thin beds of organodetrital limestones occur only sporadically. They consist of bioclasts of shallow-water organisms and lithoclasts of micritic limestones. The main allochems in these grainstone beds are *Girvanella*, vermetid gastropods, benthic ostracodes and Palaeosiphonocladales algae, derived probably from an adjacent carbonate platform. These interbeds are usually non-graded and exhibit sharp lower and upper contacts, good sorting and horizontal grain orientation, *i.e.* the features indicative of contourities (BOUMA 1972).

The thickness of the Gościno Member varies from 34 m in the Koczała-*1* section to about 120 m in the Człuchów *IG-1* section.

The base of the Gościno Member belongs to the Lower *marginifera* Zone, and its topmost parts range into the Upper *marginifera* Zone (Text-fig. 8).

THE BIELICA MEMBER

The Bielica Member is known from four sections, *i. e.* Karlino-*1*, Gorzysław-*8*, Bielica-*2*, and Chojnice-*2*. It consists of light micritic limestones, prevailing in the lower part of the sequence, with accumulation of crinoid debris, scattered ramose and "stick" bryozoans, ostracodes, patchily distributed brachiopod shells, and massive lime mudstones with scattered crinoid debris, fenestrate bryozoan fronds, colonies of dendroid tabulate corals, rare stromatoporoids and Palaeosiphonocladales algae.

Different microfacies types are noted within this very characteristic unit: crinoid-bryozoan wackestones (Pl.6, Fig. 1), crinoid wackestones and packstones (Pl. 6, Fig. 2), crinoid-brachiopod-bryozoan-ostracode wackestones to packstones/grainstones (Pl. 7, Fig. 1), stromatoporoid floatstones with *Amphipora* (Pl. 8, Fig. 1), *Baculella* bindstones, ?algal floatstones with *Baculella* (Pl. 8, Figs 3-4; *compare also* DREESEN *& al.* 1985 and MAMET 1991), bryozoan bindstones with *Fenestella* (Pl. 6, Fig. 3), tabulate coral bafflestones with ?*Multithecopora* (Pl. 8, Fig. 2), and lime mudstones with rare crinoids, fenestellid bryozoans, stromatactis-like structures and peloidal micritic crusts of probably microbial origin.

Small-scale brecciacion and fissure fillings related to neptunian dykes have also been found in some sections (Pl. 7, Figs 1-4) in the uppermost part of the Bielica Member, as well as skeletal (brachiopod-crinoid) concentrations probably formed during an episode of low net sedimentation (*see* BECKVAR & KIDWELL 1988).

Although the core material does not provide conclusive evidence for the spatial geometry of the deposits, it is likely that they are fragments of carbonate buildups. Such an interpretation is confirmed by the presence of special biota not found in other contemporaneous facies and by the occurrence of sites of increased carbonate productivity (*see* WILSON 1975; BURCHETTE 1981; LONGMAN 1981; JAMES 1983a, 1983b). Some buildups and their intermediate lateral equivalents (the deposits of the Gościno Member) show a distinct thickness relationship of 2:1 or 3:1.

The carbonate buildups in the Gorzysław-*8* and Karlino-*1* sections are 60 and 90 m thick respectively, whereas the incompletely preserved deposits of the Bielica Member in the Chojnice-*2* and Bielica-*1* sections are 150-220 m thick.

The bottom parts of the Bielica Member belongs to the Lower *marginifera* Zone, its topmost parts range into the Upper *marginifera* Zone (Text-fig. 8).

THE KROJANTY FORMATION

The Krojanty Formation overlies the Gościno, Bielica, and the Gorzysław Member, and it interfingers the deposits of the Kłanino Formation (*see* Text-fig. 8).

The Krojanty Formation represents a shallower, slightly restricted subtidal environment. Deposits consist of light gray nodular or wavy bioclastic limestones. Mudstones are present, generally in well defined beds intercalating the limestones. The grain components are represented by organic remains varying in size but the amount of bioclastic sands is relatively high. Palaeosiphonocladales algae which are represented by issinellids and palaeoberesellids (*see* Roux 1991) and plurilocular foraminifers represented by endothyrids and tournayellids, as well as calcispheres, *Girvanella* fragments, and ostracode valves are particularly common (Pl. 9, Figs 1-6). Issinellids and palaeoberesellids are the dominant fossils here, creating often a bafflestone texture. Palaeoberesellids were the most important carbonate-producing organisms in shallow, low-energy environments in late Dinantian of South Wales (*see* Adams & *al.* 1992) and seem to have occupied similar niches in late Famennian of Western Pomerania. The organisms requiring normal marine salinity (such as brachiopods and echinoderms) are not very abundant (Pl. 9, Figs 1-6). The depositional texture of the carbonate sediment varies from wackestone to packstone, and the matrix between the bioclastic grains is usually a lime-mud but occasionally it has been neomorphically altered to microsparite. It may also contain coarse sparry calcite areas.

In the upper part of the unit, the algal-foraminifer wackestones and packstones are often interbedded with algal-foraminifer-peloidal grainstones in which lime mudstone and algal wackestone intraclasts occur (Pl. 10, Figs 1-2). Horizontal grain orientation is often observed, as well as poor sorting. Megabreccias are sometimes present (*see* Text-fig. 3*B* and Pl. 9, Fig. 5).

The thickness of the Krojanty Formation in the northern part of the Western Pomerania is only several dozen to a hundred meters but the incomplete thickness of the formation in the Człuchów — Krojanty area is about several hundred meters.

The age of the Krojanty Formation has been determined as belonging to the Uppermost *marginifera*-Middle *expansa* Zones.

THE KŁANINO FORMATION

The Krojanty Formation passes to the north into the Kłanino Formation (*see* Text-fig. 8). A great variety of nearshore carbonate, peritidal and siliciclastic-evaporite facies occur within the Kłanino Formation but there are only few sections where one lithologic type is dominant over another. Generally, siliciclastic-evaporite facies prevail in the north in the Trzebusz — Kłanino area, whereas carbonates are more abundant in the Gorzysław — Karlino area (*compare* Text-figs 4 and 8).

A carbonate-dominated succession is characterized by cross-bedded somewhat dolomitic, peloidal-bioclastic grainstones with foraminifers, ostracodes, abraded crinoid debris, vermiform gastropods (Pl. 10, Fig. 3), and dasycladacean grainstones with intraclasts (*see also* J. Dadlez 1975). Some bioclasts are coated or micritized. A terrigenous quartz admixture is often present. Such a characteristic is typical of high energy shallow water shoals with sedimentation of calcareous sands (*see* Halley & *al.* 1983).

In the restricted platform interior behind the carbonate shoal, cryptocrystalline to finely crystalline dolostones as well as lime mudstones, devoid of skeletal content, with fine lamination ranging from stratiform and slightly crenulated to the arched, are observed (*see* Pl. 11, Fig. 2 and Pl. 12, Fig. 1). It is difficult to judge if the lamination is of physical or algal origin without the presence of true domal structures. However, identification of thrombolite-fenestral structures as well as the occurrence of prostrate encrusting shells of vermiform gastropods within some layers (*see* Pl. 11, Figs 1, 3 and Pl. 12, Figs 2-3) speak in favor of their microbial origin (*see* GERDES & KRUMBEIN 1987). The vermiform gastropods are significant components of Lower Carboniferous small algal-gastropod bioherms in South Wales (BURCHETTE & RIDING 1977), formed in a protected and restricted, hypersaline lagoon and resemble Recent coralline algal micro-ridges from shallow hypersaline lagoons in Tunisia, as suggested by WRIGHT & WRIGHT (1981). It seems that the algal-vermiform gastropod association has occupied similar niches in late Famennian of Western Pomerania. The algal-gastropod communities are also known from the Viséan of the Lublin Coal Basin (BEŁKA & SKOMPSKI 1982).

Mixed siliciclastic-carbonate deposits represent an interfingering of carbonate and siliciclastic tidal-flat facies. Among them, rhythmically interlayered dolomitic sandy algal-foraminiferal-crinoidal grainstones with dolomitic sandstones and laminated dolostones and lime mudstones are very common.

A siliciclastic-dominated succession is characterized by well-sorted, fine-grained dolomitic quartz sandstones, mudstones and subordinate shales. Ripple marks and low-angle cross lamination are the most important sedimentary structures (*see* Pl. 13, Figs 1-5). Quartz, fresh feldspar, mica and a very limited suit of heavy minerals as well as granitoid-type rocks fragments are observed in this sediment. Beside the sandstones and siltstones mentioned above, sandstones and siltstones with intergranular anhydrite cement also exist. The siliciclastics usually vary from gray to pink, or are sometimes red in color. The top of the siliciclastic unit includes some red-beds, *i.e.* dolomitized sandstones and mudstones with anhydrite occurring as thin beds with the characteristic "chicken-wire" texture or as nodules and crystal rosettes being the pseudomorphs after gypsum (*see* Pl. 14, Figs 1-4).

The Kłanino Formation varies in thickness from about 150 m in the Gorzysław-*8*, Karcino-*1* and Białogard-*8* sections, through 235 m in the Karlino-*1* section to about 376 m in the Kłanino-*1* section.

The lower parts of the Kłanino Formation are dated on the Lower *expansa* Zone (but it is very probable that they represent even the Uppermost *marginifera* Zone), its topmost parts belongs to the Middle *expansa* Zone (Text-fig. 8).

THE SĄPOLNO FORMATION

The Sąpolno Formation overlies the Krojanty and Kłanino formations throughout the investigated area. It is a succession of open marine carbonates and shales (*compare* Text-figs 3*B*, 4 and 8).

The formation consists of two lithofacies types in the lower, Upper Devonian part of the sequence, as follows:

(*i*) Fossiliferous marly limestones in a shallower part of the basin, *i.e.* the northern part of the area (*see* Pl. 15, Figs 1-3, 6 and Pl. 16, Figs 1-4), and

(*ii*) Fossiliferous marls with thin intercalations of organodetrital limestones in a deeper part of the basin, *i.e.* the southern part of the area (*see* Pl. 15, Figs 4-5).

The carbonate-dominated succession is characterized by dark gray marly brachiopod-crinoid wackestones interbedded with skeletal packstones composed of allochthonous bioclastic material dominated by palaeosiphonocladale algae, encrusting foraminifers, benthic ostracodes, and laminar stromatoporoids.

A predominance of marls with rare cephalopods, entomozoacean ostracodes, and conodonts as well as with such benthic organisms as trilobites, bivalves, gastropods, brachiopods, and solitary corals, interbedded with thin limestone layers composed of allochthonous bioclacstic material, characterize the marly dominated succession.

Thin layers of gray mudstones occur both in carbonate- and marly-dominated successions in the lower part of the Sąpolno Formation.

The higher, Lower Carboniferous part of the formation consists mainly of black, finely laminated shales containing relatively rare, in comparison to those of uppermost Devonian age, organic remains.

The thickness of the Sąpolno Formation varies greatly from only about 150 m in the Karcino — Karlino — Daszewo region in the northern part of the area to several hundred meters in the Babilon — Brda — Wierzchowo — Chmielno area.

The lowermost parts pf the Sąpolno Formation have been determined as belonging to the Upper *expansa* or Lower *praesulcata* Zone, the topmost parts probably belongs to the Carboniferous *?sandbergi* Zone (Text-fig. 8).

SYSTEMATIC ACCOUNT OF NEW CONODONT SPECIES

The systematic part includes only descriptions of several new species of the genera *Polygnathus* Hinde and *Alternognathus* Ziegler & Sandberg. Other taxa present in the collected fauna are only listed (*see* Text-figs 6-7) and illustrated (Pls 17-36). The monographs and revisions of almost all important Upper Devonian taxa have recently been published by Sandberg & Ziegler (1979), Sandberg & Dreesen (1984), Klapper & Lane (1985), Ziegler & Sandberg (1990), and Sandberg & *al.* (1992); their systematics therefore is not repeated herein.

All conodont specimens are kept in the collection of the Institute of Geological Sciences, Polish Academy of Sciences, Warsaw, under catalogue numbers *SMF 1-439, 640-690*, and *769-833*. Among 190 illustrated specimens almost 1/4 are re-illustrated (*compare* some figures in Pls 26-27, 29-32, and 35-36 with Pls 22.1-22.6 of Matyja 1987).

Family **Polygnathidae** Bassler, 1925
Genus *Polygnathus* Hinde, 1879

Polygnathus limbatus sp. n.
(Pl. 28, Figs 1-12)

1970. *Polygnathus* sp. n.; G. Seddon, pp. 739-740, Pl. 16, Figs 15-16.
1974. *Polygnathus* sp. A; H. Matyja & B. Żbikowska, p. 691, Pl. 6, Figs 5-6.
1985. *Polygnathus* sp. n.; H. Matyja & B. Żbikowska, Tables 1-2.
part 1986. *Polygnathus volhynicus* sp. nov.; D.M. Drygant, p. 50, Pl. 2, Figs 16, 18.

HOLOTYPE: Specimen No. *SMF 835*, presented in Pl. 28, Fig. 6.

PARATYPES: Specimens Nos *SMF 205, SMF 806, SMF 807, SMF 809, SMF 439, SMF 803, SMF 804, SMF 125, SMF 836, SMF 437, SMF 438* presented in Pl. 28, Figs 1-5 and 7-12.

TYPE LOCALITY: NW Poland, Western Pomerania, Chojnice-2 borehole section, depth interval 3099-3105 m.

TYPE HORIZON: Famennian, the Lower *marginifera* Zone.

DERIVATION OF NAME: Lat. *limbatus* — rimmed with flange.

DIAGNOSIS: The Pa element with slender, arched and asymmetrical platform, ornamented by short and weak transverse ridges; anterior platform margins upturned and slightly serrated with a very characteristic flange-like anterior outer margin distinctly higher than the carina.

MATERIAL: 23 specimens from Chojnice-*2* and Gorzysław-*8* sections (Western Pomerania), and 44 from Minkowice-*1* and Bystrzyca-*2* sections (Lublin basin).

DESCRIPTION: The Pa element is composed of a rather short free blade and a slender, arched and asymmetrical platform. The platform is almost smooth or ornamented by short and delicate transverse ridges, perpendicular to carina. Anterior platform margins are upturned and slightly serrated with a very characteristic flange-like anterior outer margin distinctly higher than the carina. Rather deep adcarinal grooves develop in the anterior half of the platform. The posterior half of the platform is arched downward and pointed at the posterior tip. Carina continues to or close to the posterior tip and consists of a row of fused denticles. Right-curved specimens are less arched and strongly ornamented than the left ones. In the lower view, the small and narrow pit is visible in anterior one fourth of the platform length.

REMARKS: The new species *Polygnathus limbatus* sp. n. differs from *Pol. semicostatus* Branson & Mehl and *Pol. obliquicostatus* Ziegler in its platform ornamentation. There are also some similarities between *Polygnathus limbatus* sp. n. and *Pol. padovanii* Perri & Spaletta both in their platform outline and upper surface ornamentation (*see* Perri & Spaletta 1990); *Polygnathus limbatus* sp. n., however, possesses a very characteristic flange-like anterior outer margin. Moreover, its basal pit is smaller and narrower than in *Polygnathus padovanii*. Taking into account the stratigraphic ranges of both species, as well as the similarities between them, it is possible to assume that *Polygnathus limbatus* sp. n. may be an ancestor of *Polygnathus padovanii* which is known from the Upper *marginifera* up to the Lower *trachytera* Zone.

OCCURRENCE: Famennian, the *crepida* Zone (Lublin basin) and *marginifera* Zone (Lublin basin and Western Pomerania).

Polygnathus pomeranicus sp. n.
(Pl. 29, Figs 5-7 and Pl. 30, Figs 1-3)

1972. *Polygnathus* aff. *procerus* Sannemann; H. Matyja, p. 747, Pl. 4, Figs 8-9.
1987. *Polygnathus* aff. *procerus* Sannemann; H. Matyja, Pl.22.2, Fig. 5; Pl. 22.3, Fig. 4.

HOLOTYPE: Specimen No. *SMF 133*, presented in Pl. 29, Fig. 5.
PARATYPES: Specimens No. *SMF 161*, *SMF 134*, presented in Pl. 29, Figs 6-7, and No. *SMF 790*, *SMF 802* and *SMF 789*, presented in Pl. 30, Figs 1-3, respectively.
TYPE LOCALITY: NW Poland, Western Pomerania, Chojnice-2 borehole section, depth interval 3117-3124 m.
TYPE HORIZON: Famennian, the Lower *marginifera* Zone.
DERIVATION OF NAME: To indicate the region where this species was first recognized.

DIAGNOSIS: The Pa element characterized by a long, narrow and smooth platform with high, upturned and thickened lateral margins which are shagreen-like on their upper surface, and by a free blade distincly shorter than the platform length.

MATERIAL: 70 specimens from Gorzysław-*8*, Karcino-*1*, Karlino-*1*, Człuchów *IG-1*, Krojanty-*1*, Chojnice-*2*, Chojnice-*4*, and Chojnice-*5* sections.

DESCRIPTION: The Pa element is composed of short free blade consisting of several, laterally compressed, denticles of approximately equal height, and a long, narrow and smooth platform. In the upper view the platform is characterized by high, upturned lateral margins, strongly thickened and shagreen-like on their upper surfaces, and long, deep and narrow adcarinal grooves. The medial carina is a ridge formed by low, highly fused nodes, and extending to or close to the posterior tip. The basal pit is at or close to the anterior end of the platform and it possesses raised broad rims in all growth stages.

REMARKS: Almost all specimens of *Polygnathus pomeranicus* sp. n. are of a small-size; nevertheless, they are so consistent in the platform outline and in lack of ornamentation that they cannot represent juveniles of some larger species. Right-curved specimens are wider than the left-curved ones. Specimens in collection represent two morphotypes: (*i*) more numerous morphotypes (Pl. 29, Figs 5-7) which have a very narrow, smooth platform and a complete carina, and (*ii*) rare morphotypes with wider platform in which the carina does not reach the posterior end, and with outer anterior margin very discretely serrated (Pl. 30, Figs 1-3).

OCCURRENCE: Famennian, Lower to Uppermost *marginifera* Zone, rare in the Upper *postera* or Lower *expansa* Zone.

Polygnathus praecursor sp. n.
(Pl. 24, Figs 12-13 and Pl. 25, Fig. 4)

1992b. *Polygnathus* aff. *planirostratus* DREESEN & DUSAR; H. MATYJA & M. NARKIEWICZ, Pl. 2, Figs 4-7.

HOLOTYPE: Specimen No. *SMF 210* presented in Pl. 24, Fig. 13.

PARATYPES: Specimens Nos *SMF 212* and *SMF 32*, presented in Pl. 24, Fig. 12 and Pl. 25, Fig. 4.

TYPE LOCALITY: NW Poland, Western Pomerania, Unisław-2 borehole section, depth interval 4636-4637 m.

TYPE HORIZON: Famennian, Lower or Middle *triangularis* Zone.

DERIVATION OF NAME: Lat. *praecursor* — ancestor; refers to the Author's suggestion that all Famennian conodonts belonging to the *Polygnathus semicostatus* group evolved from *Polygnathus praecursor* sp. n.

DIAGNOSIS: The Pa element composed of a rather short free blade and an arched, asymmetrical and vayring in shape, elongated platform, often devoid of any sculpture in its anterior part, covered in the middle part by very distinct, sharp-edged, often irregular, ridges and by pointed nodes in the posterior part.

MATERIAL: 28 specimens from the Gorzysław-*14* and Unisław-*2* sections.

DESCRIPTION: The Pa element is composed of a rather short free blade with several high, laterally compressed, denticles and an arched, asymmetrical, varying in outline, long platform. In its anterior part raised margins, often devoid of any sculpture, form rather shallow adcarinal grooves on both sides of the carina. The platform is covered in its middle part by distinct, sharp-edged and irregular ridges, and by nodes in the posterior one third. Posterior tip is rounded or pointed. Carina usually continues to the posterior tip, but it may be uncomplete in some specimens. Small basal pit develops on the lower surface of the platform.

REMARKS: Differentiation of the platform into the narrow, almost smooth anterior, and the slightly wider but strongly sculptured middle and posterior parts is characteristic for the

Polygnathus semicostatus group (e.g., *Polygnathus semicostatus* BRANSON & MEHL, *Pol. szulczewskii* MATYJA, *Pol. planirostratus* DREESEN & DUSAR, *Pol. orientalis* GAGIEV, KONONOVA & PAZUHIN) to which the new species here described should be classified as well. In general platform outline and in mode of ornamentation, *Polygnathus praecursor* sp. n. resembles *Pol. szulczewskii* (*see* MATYJA 1974), from which it differs in having a tendency to an instable platform outline and ornamentation. Moreover, the ornamentation is irregular, very distinct and with relatively sharp ridges and nodes on the upper surface of the platform.

OCCURRENCE: Famennian, the *triangularis* Zone.

Family **Elictognathidae** AUSTIN & RHODES, 1981

Genus *Alternognathus* ZIEGLER & SANDBERG, 1984

Alternognathus costatiformis sp. n.

(Pl. 33, Figs 4-7)

HOLOTYPE: Specimen No. *SMF 789* presented in Pl. 33, Fig. 4.

PARATYPES: Specimens Nos *SMF 787*, *SMF 788*, *SMF 785*, presented in Pl. 33, Figs 5-7.

TYPE LOCALITY: NW Poland, Western Pomerania, Człuchów *IG-1* borehole section, depth interval 2996-2997 m.

TYPE HORIZON: Famennian, the Lower *expansa* Zone.

DERIVATION OF NAME: Refers to the similarity with "*Icriodus*" *costatus* (THOMAS) in platform shape and ornamentation.

DIAGNOSIS: The Pa element characterized by a relatively narrow platform with aligned transverse ridges formed by fusion of side-row and median-row denticles, and a free blade which is slightly offset to the left side of the carina and the highest at its midlength.

MATERIAL: 4 specimens from Człuchów *IG-1* section.

DESCRIPTION: The Pa element is characterized by a relatively narrow platform, and by a free blade which is slightly offset, generally to the left side of the carina and the highest at its midlength. Upper surface covered by strong, transverse ridges formed by fusion of side-row and medial-row denticles. The denticles of the medial row are discrete and circular in upper view. The side rows of denticles are very distinct and ridge-like. Left- and right-side denticles are very similar in shape and height except the most anterior ones. The most anterior, righ-side denticle is the strongest and protrudes laterally, whereas the most anterior left-side denticle is reduced. Small specimens possess an open basal cavity (*see* Pl. 33, Figs 5-7), whereas in the large specimen (Pl. 33, Fig. 4) the basal cavity everts into pseudokeel with an unlipped basal pit near the anterior end of the platform.

REMARKS: In the general platform outline *Alternognathus costatiformis* sp. n. is most closely related to *Alt. regularis* ZIEGLER & SANDBERG. It can be distinguished from the latter by its very characteristic upper surface ornamentation composed of aligned transverse ridges, similar to ornamentation of "*Icriodus*" *costatus costatus* (THOMAS). Taking into account the stratigraphic ranges of both species of the genus *Alternognathus*, it is possible to assume that *Alt. costatiformis* sp. n. may be a descendant of *Alt. regularis*, which is known from the Uppermost *marginifera* Zone up to the Upper *postera* Zone (*see* ZIEGLER & SANDBERG 1984b).

OCCURRENCE: Famennian, the Lower *expansa* Zone.

BIOSTRATIGRAPHY

The biostratigraphic analysis of the Upper Devonian and lowermost Carboniferous deposits in Western Pomerania is based mainly on conodonts, supplemented by age determinations based on the entomozoacean ostracodes (ŻBIKOWSKA 1986, 1992) and miospores (TURNAU 1978, 1979; MATYJA & TURNAU 1989; CLAYTON & TURNAU 1990; AVCHIMOVITCH & *al.* 1993).

Since the comprehensive work of RABIEN (1954) the great value of the Entomozoacea, the so-called fingerprint ostracodes, for the European Upper Devonian and Lower Carboniferous biostratigraphy is undisputed. The stratigraphic distribution of the Upper Devonian and Lower Carboniferous entomozoaceans has been summarized recently by GROSS-UFFENORDE (1984), GROSS-UFFENORDE & WANG (1989), GROSS-UFFENORDE & SCHINDLER (1990) and GROSS-UFFENORDE (1990). The entomozoacean zonation is easy to correlate with conodont subdivisions (*see* Text-fig. 5).

Entomozoaceans are thought to have been planktic and characterize a pelagic environment. Representatives of this group have sometimes entered the shelf facies where they indicate rather deeper shelf environment.

The Upper Devonian deposits of Western Pomerania bear rare entomozoaceans and the state of their preservation is usually poor. Nevertheless, 16 species have been recognized by ŻBIKOWSKA (1986, 1992). They are limited to some horizons only, and represent six entomozoacean zones: *cicatricosa*, *sartenaeri*, *sigmoidale*, *intercostata*, *hemisphaerica-dichotoma*, and *latior* (ŻBIKOWSKA 1986, 1992). The age of almost all entomozoacean-bearing intervals have been confirmed by means of conodonts (*see* Text-figs 3-4).

Local palynological zonation have been established by TURNAU (1978, 1979) for the Famennian and Carboniferous deposits of Western Pomerania.

PLATE 17

Frasnian conodonts of the *punctata* Zone

1 — *Polygnathus alatus* HUDDLE, 1934; SMF 409 (borehole Jamno *IG-1*, depth interval 1875-1881 m), × 100
2 — *Polygnathus ?webbi* STAUFFER, 1938; SMF 412, juvenile specimen (*ibidem*, 1917-1918 m), × 250
3 — *Polygnathus* sp.; SMF 410, a new species or a bizzare, gerontic individual of *Polygnathus alatus* HUDDLE (*ibidem*, 1882-1883 m), × 75
4 — *Icriodus subterminus* YOUNGQUIST, 1947; SMF 408 (*ibidem*, 1700-1701 m), × 200
5 — *Polygnathus pacificus* SAVAGE & FUNAI, 1980; SMF 411 (*ibidem*, 1917-1918 m), × 100
6 — *Polygnathus ?webbi* STAUFFER, 1938; SMF 407, ?gerontic specimen (*ibidem*, 1702-1703 m), × 75

All upper views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Frasnian conodonts of the Upper *hassi* — Lower *rhenana* Zones

1-3 — *Polygnathus evidens* KLAPPER & LANE, 1985; 1 — SMF 397 (borehole Unisław *2*, depth interval 4973-4974 m), × 33; 2 — SMF 384 (*ibidem*, 4917-4718 m), × 65; 3 — SMF 395 (*ibidem*, 4973-4974 m), × 73

4-6 — *Polygnathus ?alatus* HUDDLE, 1934; 4 — SMF 403 (*ibidem*), × 53; 5 — SMF 401 (*ibidem*), × 37; 6 — SMF 402 (*ibidem*), × 67

7 — *Polygnathus robustus* KLAPPER & LANE, 1985; SMF 396 (*ibidem*), × 42

8-9 — *Icriodus symmetricus* BRANSON & MEHL, 1934; 8 — SMF 394 (*ibidem*), × 100; 9 — SMF 385 (*ibidem*, 4717-4718 m), × 100

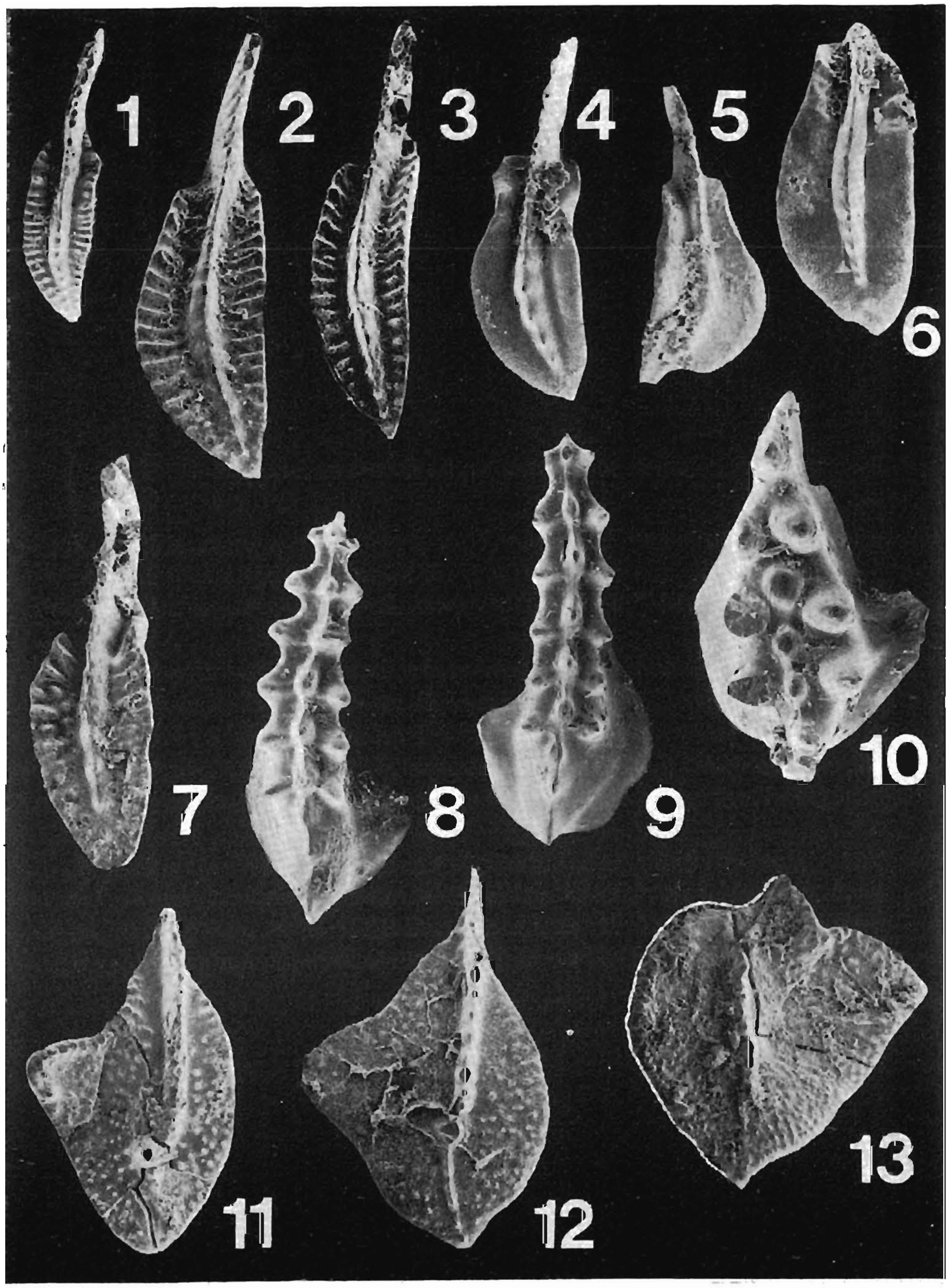
10 — *Icriodus subterminus* YOUNGQUIST, 1947; SMF 393 (*ibidem*, 4973-4974 m), × 120

11 — *Palmatolepis proversa* ZIEGLER, 1958; SMF 404 (*ibidem*), × 52

12 — *Palmatolepis hassi* MÜLLER & MÜLLER, 1957; SMF 386 (*ibidem*, 4717-4718 m), × 60

13 — *Palmatolepis plana* ZIEGLER & SANDBERG, 1990; SMF 406 (*ibidem*, 4973-4974 m), × 30

All upper views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Frasnian conodonts of the Lower *rhenana* Zone

1 — *Polygnathus decorosus* Stauffer, 1938; SMF 196 (borehole Chojnice *3*, depth interval 2793-2798 m), × 72

2 — *Polygnathus brevilaminus* Branson & Mehl, 1934; SMF 423 (*ibidem*, 2742-2743 m), × 100

3-4 — *Polygnathus alatus* Huddle, 1934; 3 — SMF 413 (*ibidem*, 2672-2680 m), × 90; 4 — SMF 192 (*ibidem*, 2722-2724 m), × 54

5 — *Palmatolepis simpla* Ziegler & Sandberg, 1990; SMF 194, juvenile specimen (*ibidem*, 2783-2786 m), × 72

6 — *Polygnathus evidens* Klapper & Lane, 1985; SMF 414 (*ibidem*, 2672-2680 m), × 75

7 — *Icriodus symmetricus* Branson & Mehl, 1934; SMF 426 (*ibidem*, 2783-2786 m), × 120

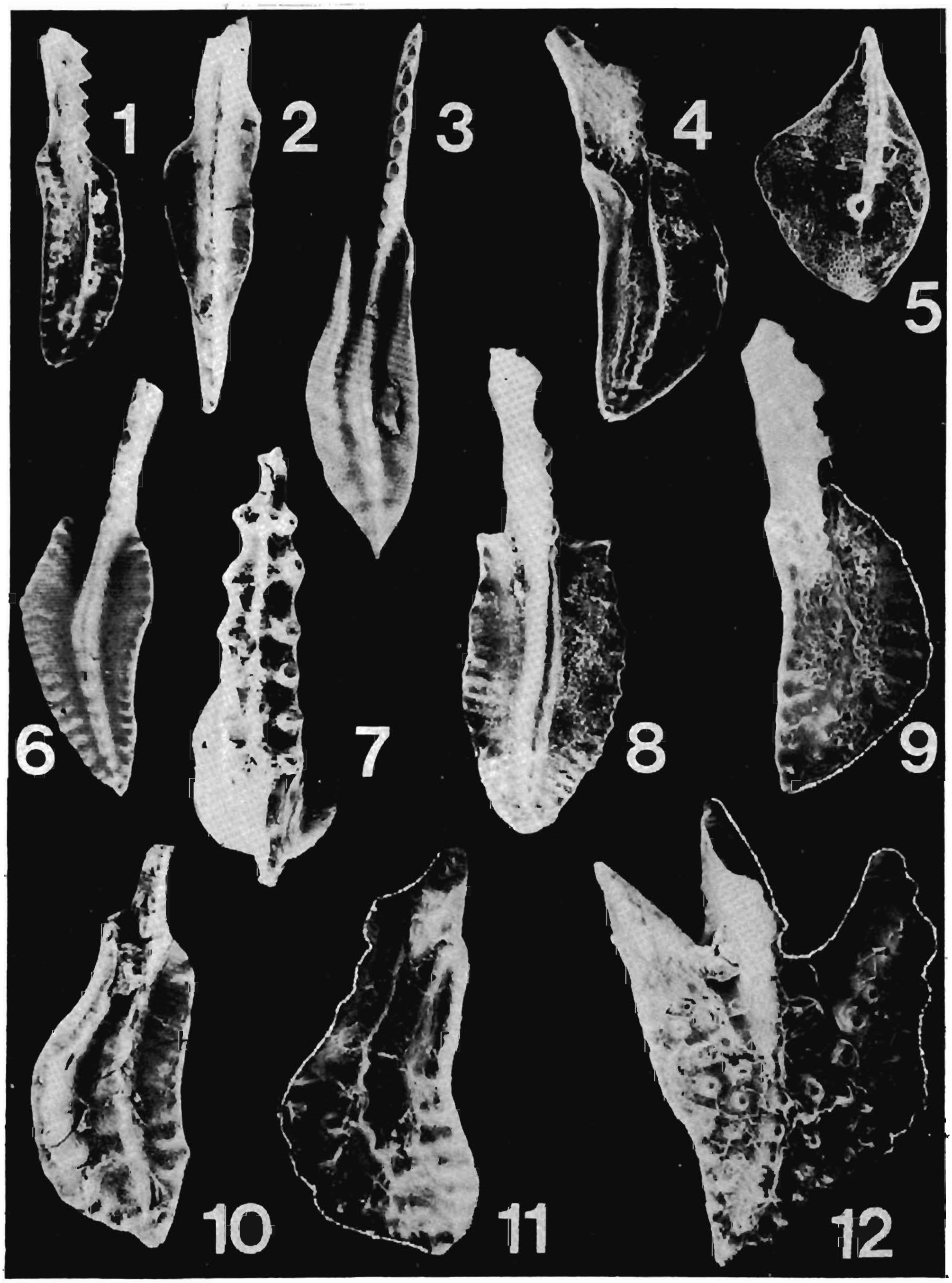
8 — *Polygnathus robustus* Klapper & Lane, 1985; SMF 190 (*ibidem*, 2672-2680 m), × 54

9 — *Polygnathus morgani* Klapper & Lane, 1985; SMF 191 (*ibidem*, 2698-2702 m), × 54

10-11 — *Polygnathus aequalis* Klapper & Lane, 1985; 10 — SMF 425 (*ibidem*, 2783-2786 m), × 60; 11 — SMF 195 (*ibidem*), × 54

12 — *Ancyrodella lobata* Branson & Mehl, 1934; SMF 193 (*ibidem*), × 54

All upper views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Frasnian conodonts of the Lower *rhenana* Zone

1 — *Polygnathus decorosus* Stauffer, 1938; SMF 376 (borehole Unisław *2*, depth interval 4692-4693 m), × 65

2 — *Polygnathus evidens* Klapper & Lane, 1985; SMF 366 (*ibidem*, 4688-4689 m), × 48

3 — *Polygnathus pacificus* Savage & Funai, 1980; SMF 367 (*ibidem*), × 74

4-5 — *Palmatolepis punctata* (Hinde, 1879); 4 — SMF 352 (*ibidem*), × 40; 5 — SMF 344 (*ibidem*), × 70

6 — *Palmatolepis barba* Ziegler & Sandberg, 1990; SMF 342 (*ibidem*), × 70

7 — *Ancyroides leonis* Sandberg, Ziegler & Dreesen, 1992; SMF 362 (*ibidem*), × 46

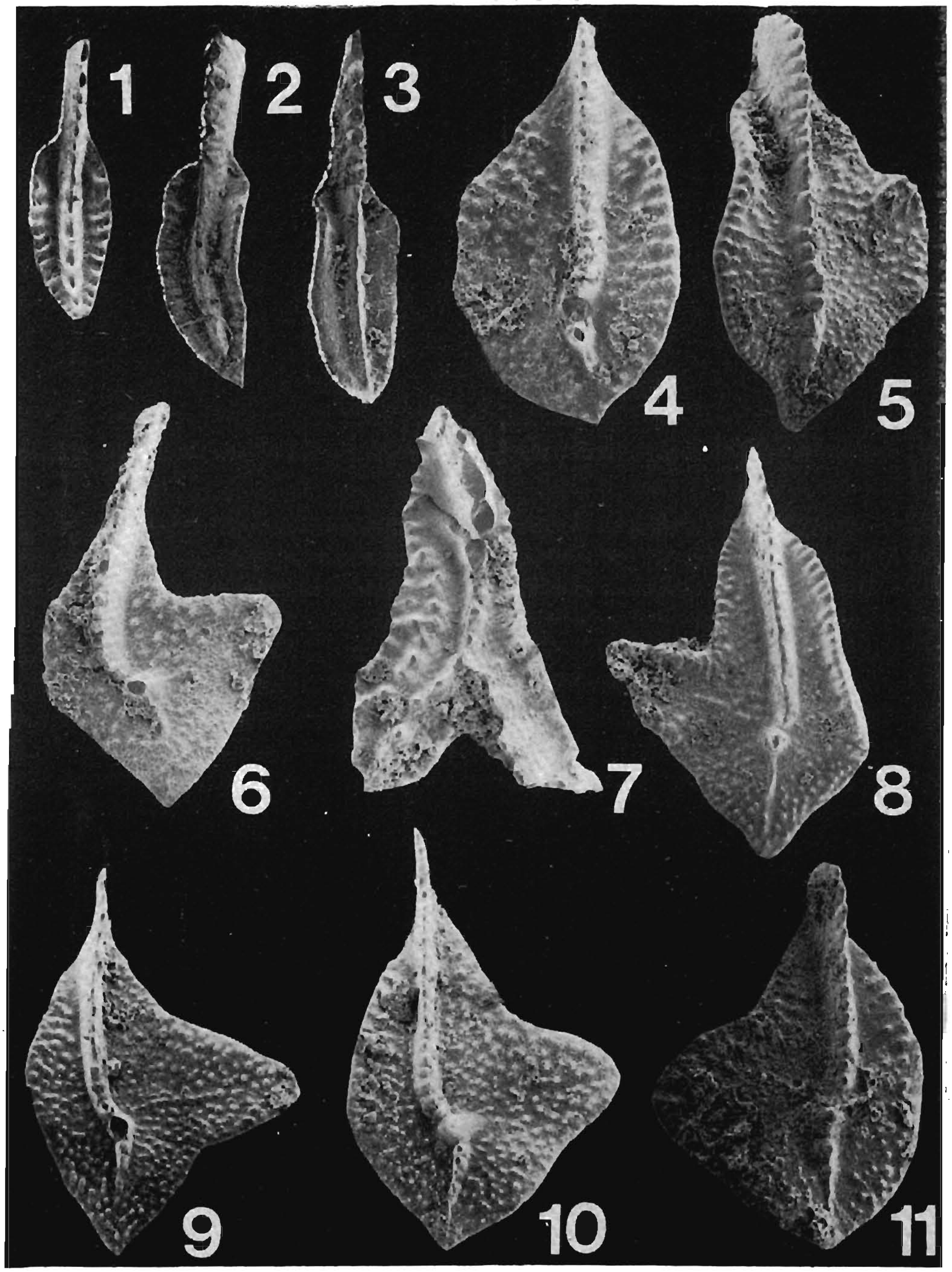
8 — *Palmatolepis proversa* Ziegler, 1958; SMF 353 (*ibidem*), × 39

9 — *Palmatolepis rhenana nasuta* Müller, 1956; SMF 355 (*ibidem*), × 35

10 — *Palmatolepis hassi* Müller & Müller, 1957; SMF 347 (*ibidem*), × 100

11 — *Palmatolepis plana* Ziegler & Sandberg, 1990; SMF 349 (*ibidem*), × 50

All upper views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Frasnian conodonts of the Upper *rhenana* Zone

1 — *Ancyrognathus triangularis* Youngquist, 1945; SMF 335 (borehole Unisław 2, depth interval 4669-4670 m), × 52

2 — *Ancyrodella gigas* Youngquist, 1947; SMF 318 (*ibidem*, 4663-4664 m), × 40

3, 10 — *Ancyrodella nodosa* Ulrich & Bassler, 1926; 3 — SMF 361 (*ibidem*), × 35; 10 — SMF 316 (*ibidem*), × 54

4-5 — *Palmatolepis rhenana nasuta* Müller, 1956; 4 — SMF 329 (*ibidem*, 4669-4670 m), × 50; 5 — SMF 328 (*ibidem*), × 65

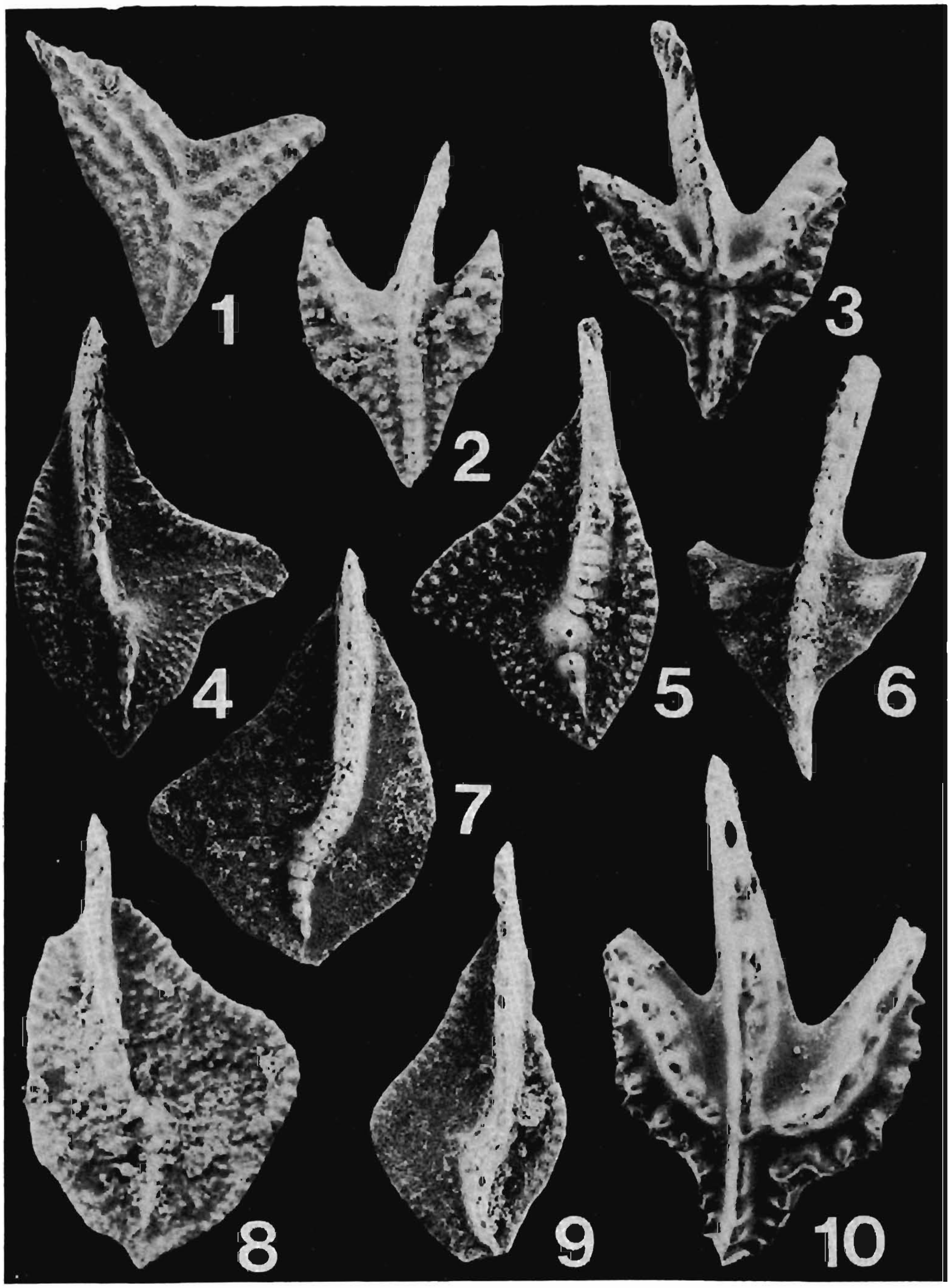
6 — *Ancyrodella* sp.; SMF 338, juvenile specimen (*ibidem*, 4671-4672 m), × 110

7 — *Palmatolepis jamieae* Ziegler & Sandberg, 1990; SMF 330 (*ibidem*, 4669-4670 m), × 70

8 — *Palmatolepis plana* Ziegler & Sandberg, 1990; SMF 321 (*ibidem*, 4663-4664 m), × 54

9 — *Palmatolepis foliacea* Youngquist, 1945; SMF 331 (*ibidem*, 4669-4670 m) × 63

All upper views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Frasnian conodonts of the Upper *rhenana* Zone

1 — *Palmatolepis rotunda* Ziegler & Sandberg, 1990; SMF 20 (borehole Gorzysaw *8*, depth interval 3800-3802 m), × 90

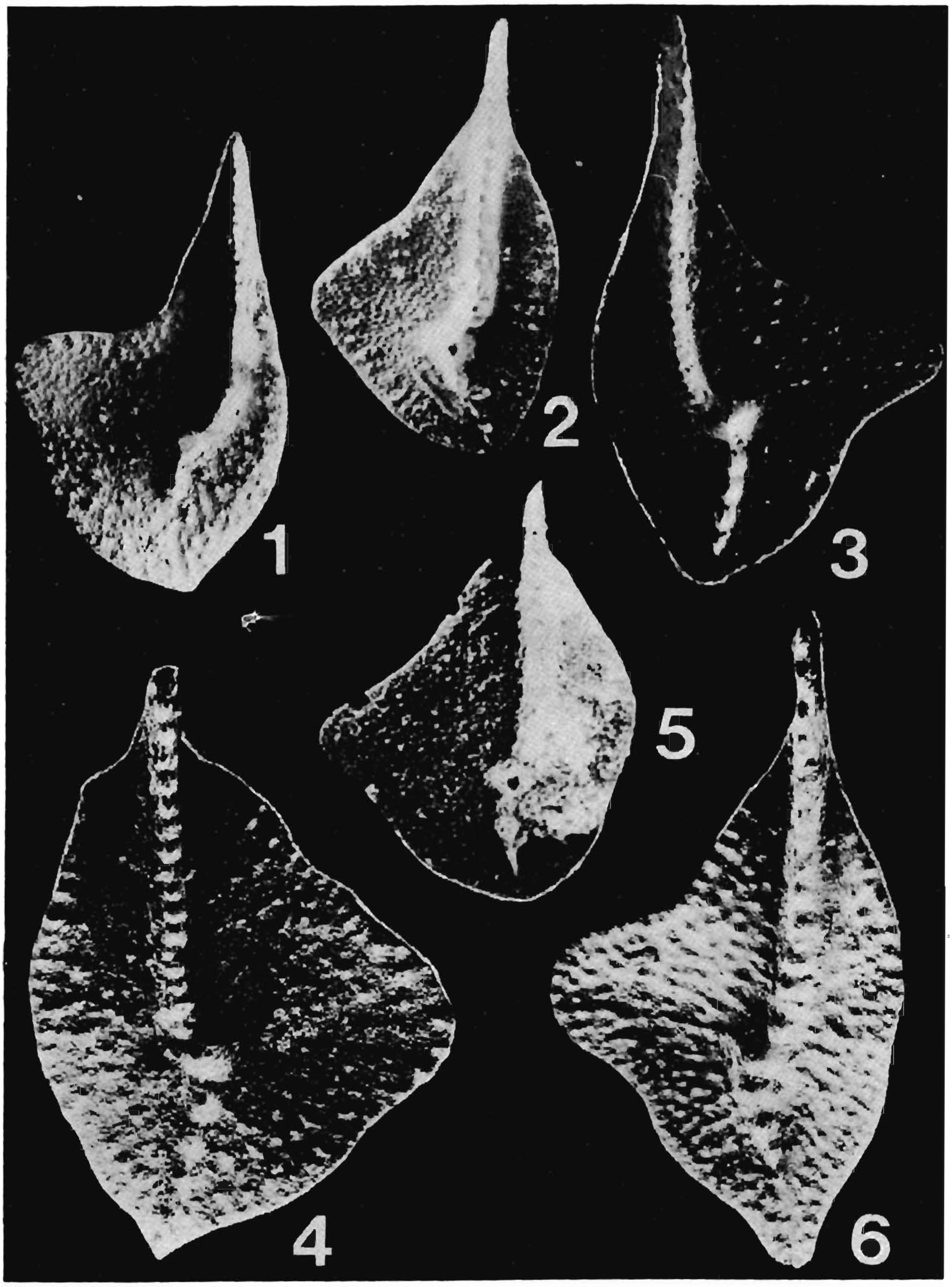
2 — *Palmatolepis subrecta* Miller & Youngquist, 1947; SMF 36 (Strzeżewo *1*, 4104-4109 m), × 90

3 — *Palmatolepis rhenana nasuta* Müller, 1956; SMF 19 (Gorzysław *8*, 3800-3802 m), × 90

4-5 — *Palmatolepis jamieae* Ziegler & Sandberg, 1990; 4 — SMF 33 (Strzeżewo *1*, 4104-4109 m), × 90; 5 — SMF 35 (*ibidem*), × 90

6 — *Palmatolepis hassi* Müller & Müller, 1954; SMF 32 (*ibidem*), × 90

All upper views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Frasnian conodonts of the ?*linguiformis* Zone

1-2 — *Mehlina gradata* Youngquist, 1945; 1 — SMF 315, lateral view (borehole Unisław 2, depth interval 4647-4648 m); 2 — SMF 314, lateral view (*ibidem*), × 94

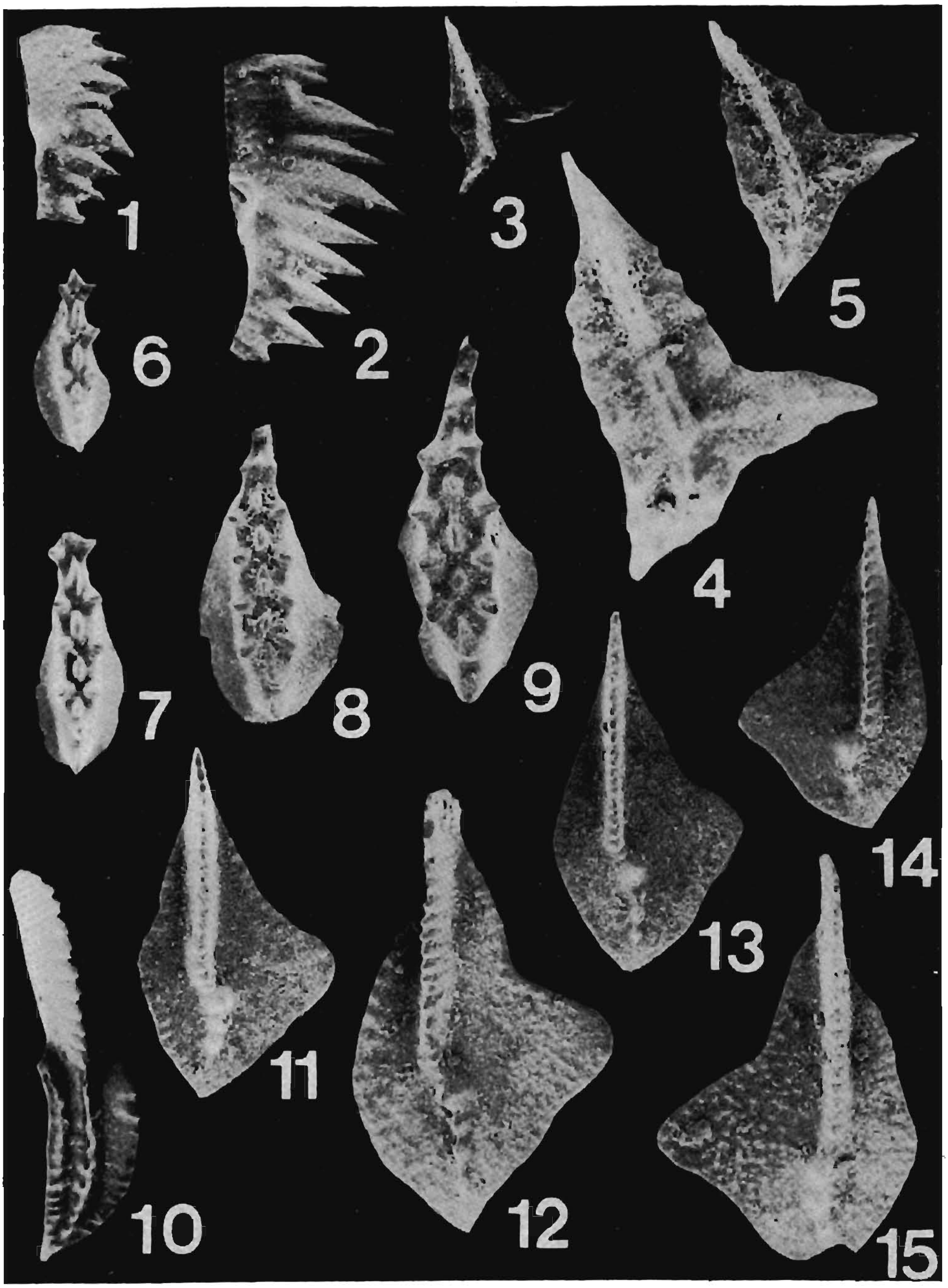
3-5 — *Ancyrognathus triangularis* Youngquist, 1945; 3 — SMF 294, juvenile specimen (*ibidem*), × 78; 4-5 — SMF 299, 297 (*ibidem*), × 78

6-9 — *Icriodus alternatus alternatus* Branson & Mehl, 1934; 6-7 — SMF 293, 291, juvenile specimens (*ibidem*), × 78; 8-9 — SMF 287, 286 (*ibidem*), × 78

10 — *Polygnathus webbi* Stauffer, 1938; SMF 306 (*ibidem*), × 66

11-15 — *Palmatolepis subrecta* Miller & Youngquist, 1947; SMF 263, 259, 266, 267, 254 (*ibidem*), × 60

Upper views, unless otherwise stated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Famennian conodonts of the Lower — Middle *triangularis* Zones

1 — "*Icriodus*" cornutus Sannemann, 1955; SMF 217 (borehole Unisław *2*, depth interval 4635-4636 m), × 100

2-3 — *Icriodus alternatus alternatus* Branson & Mehl, 1934; 2 — SMF 219 (*ibidem*, 4636-4637 m), × 100; 3 — SMF 229 (*ibidem*), × 94

4 — *Icriodus alternatus helmsi* Sandberg & Dreesen, 1984; SMF 247 (*ibidem*, 4643-4644 m), × 78

5 — *Icriodus iowanensis iowanensis* Youngquist & Peterson, 1947; SMF 227 (*ibidem*, 4636-4637 m), × 94

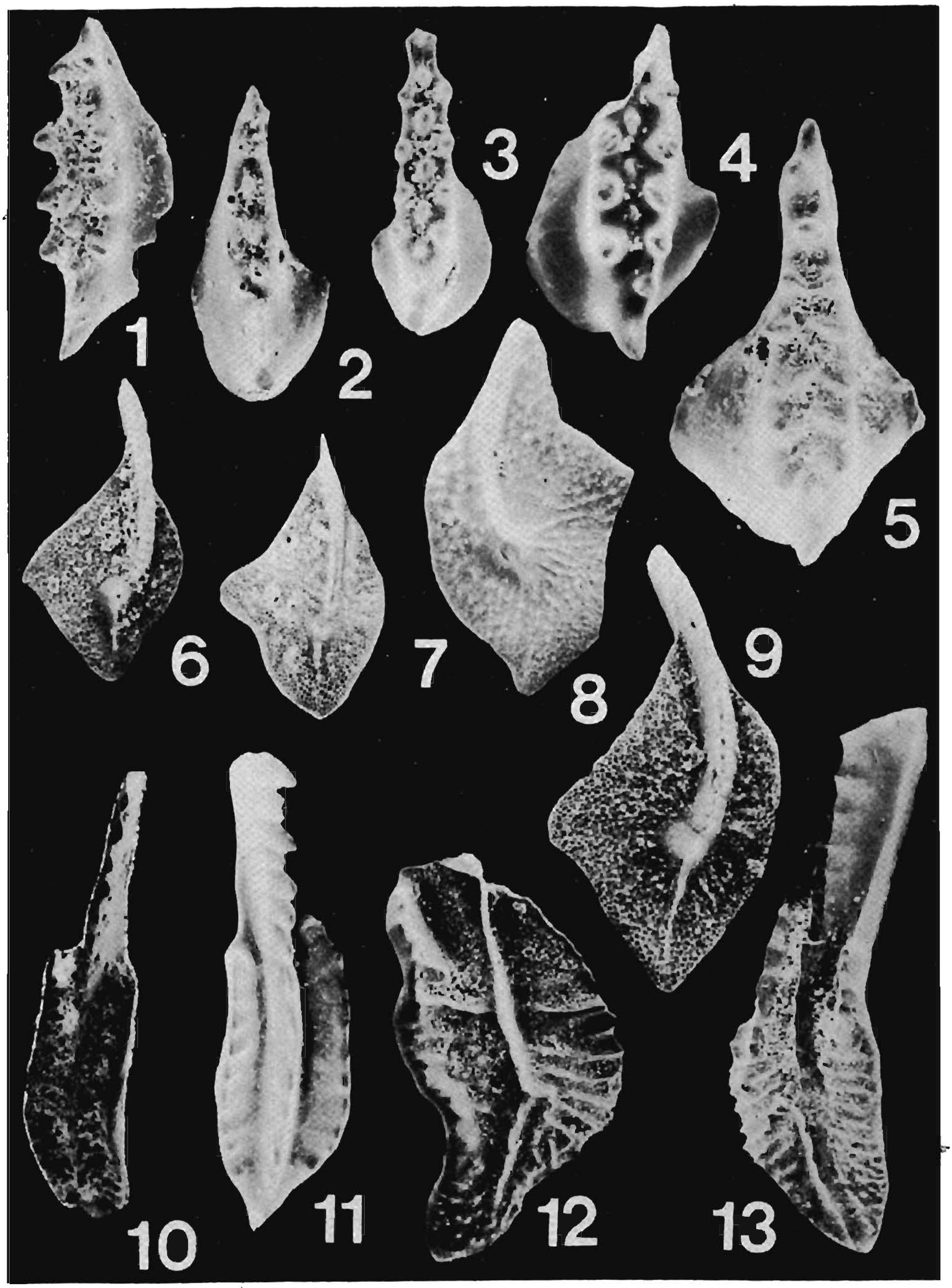
6-9 — *Palmatolepis triangularis* Sannemann, 1955; 6 — SMF 209, juvenile specimen (*ibidem*), × 94; 7 — SMF 243 (*ibidem*, 4643-4644 m), × 66; 8 — SMF 200 (*ibidem*, 4636-4637 m), × 66; 9 — SMF 208, juvenile specimen (*ibidem*), × 94

10 — *Polygnathus procerus* Sannemann, 1955; SMF 216 (*ibidem*), × 86

11 — *Polygnathus brevilaminus* Branson & Mehl, 1934; SMF 245 (*ibidem*), × 66

12-13 — *Polygnathus praecursor* sp. n.; 12 — **paratype**, SMF 212 (*ibidem*), × 48; 13 — **holotype**, SMF 210 (*ibidem*), × 40; re-illustration of specimens illustrated as *Polygnathus* aff. *planirostratus* Dreesen & Dusar, 1974 by Matyja & Narkiewicz (1992, Pl. 2, Figs 7 and 5)

All upper views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Famennian conodonts of the Upper *triangularis* Zone

1-3 — *Icriodus alternatus alternatus* BRANSON & MEHL, 1934; 1, 3 — SMF 27, 28, specimens with a broad cup (borehole Gorzysław *14*, depth interval 2854-2865 m), × 60, × 90; 2 — SMF 26 (*ibidem*), × 60

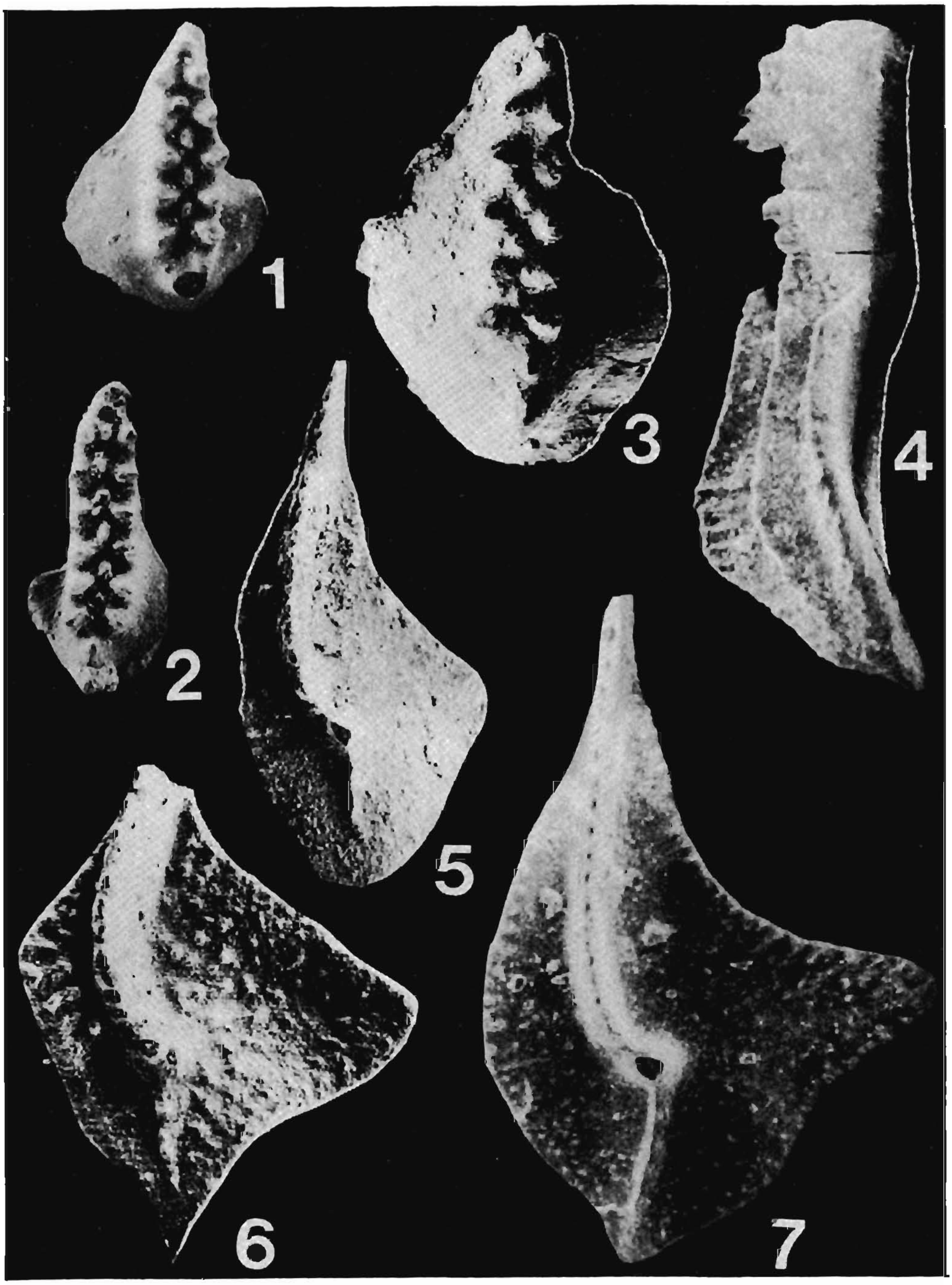
4 — *Polygnathus praecursor* sp. n.; **paratype**, SMF 32 (*ibidem*, 2865-2882 m), × 60

5 — *Palmatolepis minuta minuta* BRANSON & MEHL, 1934; SMF 31, (*ibidem*), × 90

6 — *Palmatolepis triangularis* SANNEMANN, 1955 → *Palmatolepis quadrantinodosalobata* SANNEMANN, 1955; SMF 29 (*ibidem*, 2854-2865 m), × 150

7 — *Palmatolepis triangularis* SANNEMANN, 1955; SMF 30 (*ibidem*, 2865-2882 m), × 90

All upper views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Famennian conodonts of the Lower — Upper *crepida* Zones

1 — *Polygnathus procerus* Sannemann, 1955; SMF 155 (borehole Karsina *1*, depth interval 2812-2814 m), × 94

2 — *Alternognathus* sp.; 2a — SMF 61 (Koczała *1*, 2286-2292 m), × 90; 2b — SMF 186, lower view (*ibidem*), × 94

3 — *Palmatolepis crepida* Sannemann, 1955; SMF 151 (Karcino *2*, 2938-2939 m), × 60; re-illustrated from Matyja (1987, Pl. 22.1, Fig. 6)

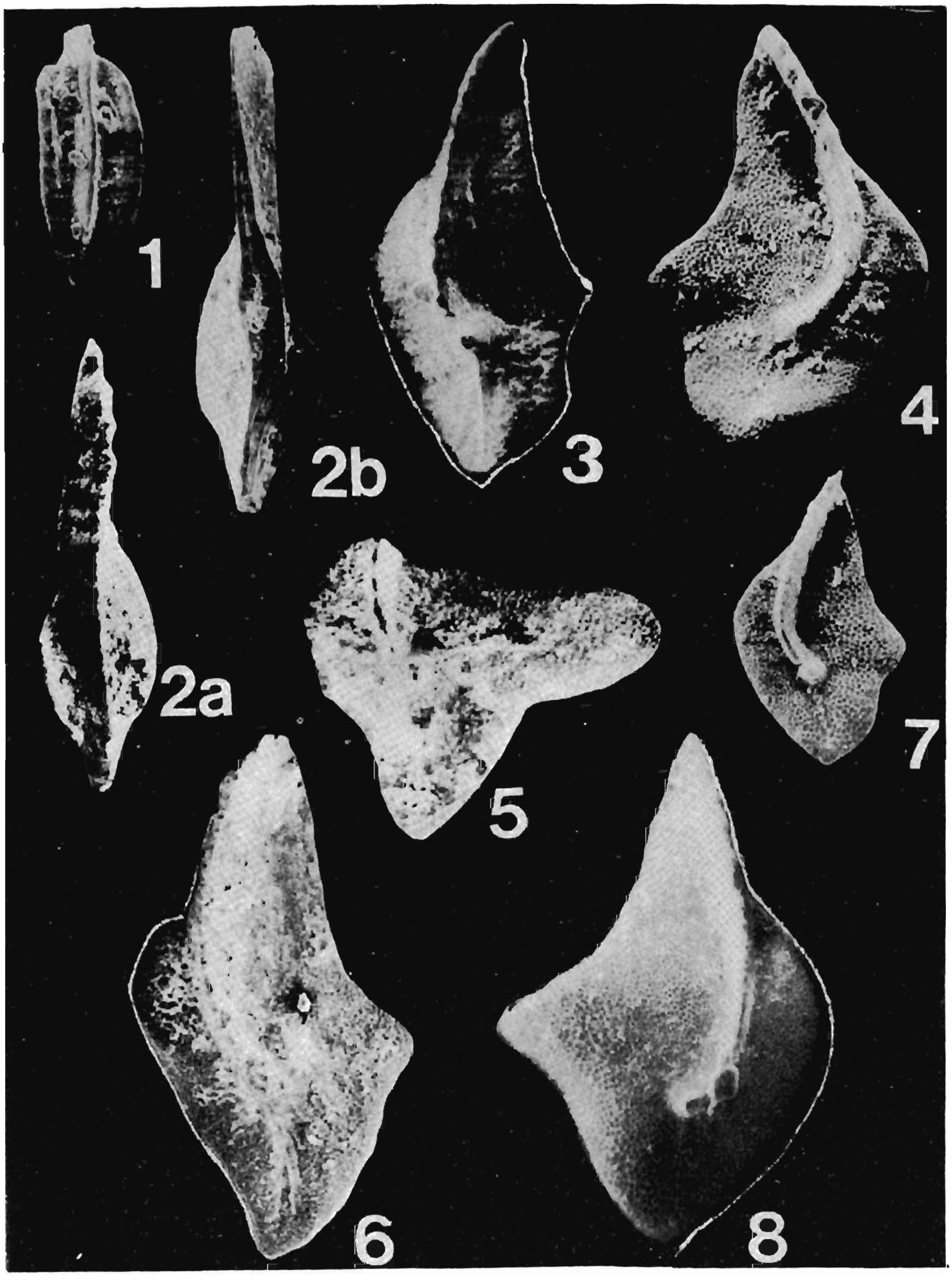
4 — *Palmatolepis circularis* Szulczewski, 1971; SMF 157 (Karsina *1*, 2812-2814 m), × 94; re-illustrated from Matyja (1987, Pl. 22.1, Fig. 2)

5 — *Palmatolepis quadrantinodosalobata* Sannemann, 1955; SMF 63 (Koczała *1*, 2332-2337 m), × 90

6 — *Palmatolepis tenuipunctata* Sannemann, 1955; SMF 62 (*ibidem*, 2286-2292 m), × 90; re-illustrated from Matyja (1987, Pl. 22.1, Fig. 7)

7-8 — *Palmatolepis wolskajae* Ovnatanova, 1969; 7 — SMF 154 (Karsina *1*, 2812-2814 m), × 94; 8 — SMF 153, specimen showing tendency toward *Palmatolepis circularis* (*ibidem*, 2873-2875 m), × 94; re-illustrated from Matyja (1987, Pl. 22.1, Figs 1 and 3)

Upper views, unless otherwise stated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Famennian conodonts of the Upper *rhomboidea* Zone (Figs 4 and 7) and Lower *marginifera* Zone (Figs 1-3, 5-6, 8-13)

1-4 — "*Icriodus*" *chojnicensis* MATYJA, 1972; 1 — SMF 132 (borehole Chojnice *2*, depth interval 3111-3117 m), × 94; 2 — SMF 124 (*ibidem*, 3099-3105 m), × 94; 3 — SMF 131 (*ibidem*, 3117-3123 m), × 94; re-illustrated from MATYJA (1987, Pl. 22.1, Figs 3, 1, 2); 4 — SMF 792, lateral (a) and upper (b) views of a juvenile specimen (Chojnice *5*, 3110-3112 m), × 165

5 — *Palmatolepis marginifera marginifera* HELMS, 1959; SMF 136 (Chojnice *2*, 3154-3160 m), × 40; re-illustrated from MATYJA (1987, Pl. 22.2, Fig. 10)

6 — *Palmatolepis quadrantinodosa inflexa* MÜLLER, 1956, SMF 120 (*ibidem*, 3142-3148 m), × 94; re-illustrated from MATYJA (1987, Pl.22.2, Fig. 16)

7 — *Palmatolepis rhomboidea* SANNEMANN, 1955; SMF 793 (Chojnice *5*, 3110-3112 m), × 100

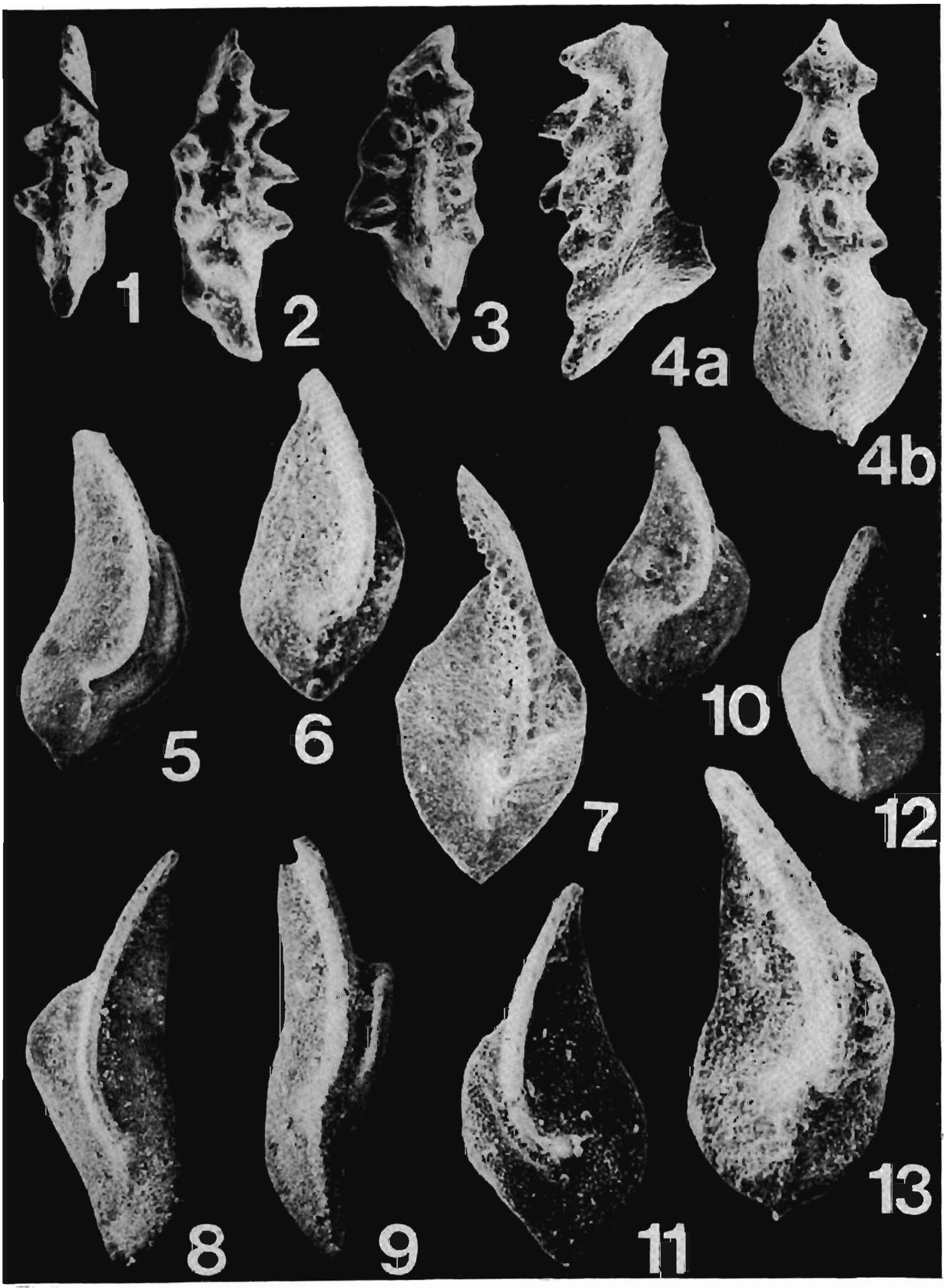
8 — *Palmatolepis quadrantinodosa inflexoidea* ZIEGLER, 1962; SMF 121 (Chojnice *2*, 3093-3099 m), × 40; re-illustrated from MATYJA (1987, Pl. 22.3, Fig. 13)

9 — *Palmatolepis glabra pectinata* ZIEGLER, 1962; SMF 139 (*ibidem*, 3160-3167 m), × 40; re-illustrated from MATYJA (1987, Pl. 22.2, Fig. 17)

10-11 — *Palmatolepis stoppeli* SANDBERG & ZIEGLER, 1973; 10 — SMF 126 (*ibidem*, 3142-3148 m), × 94; 11 — SMF 135 (*ibidem*, 3148-3154 m), × 40; re-illustrated from MATYJA (1987, Pl. 22.2, Figs 15 and 14)

12-13 — *Palmatolepis quadrantinodosa quadrantinodosa* BRANSON & MEHL, 1934; 12 — SMF 138 (*ibidem*, 3160-3167 m), × 40; 13 — SMF 137 (*ibidem*, 3154-3160 m), × 94; re-illustrated from MATYJA (1987, Pl. 22.2, Figs 9 and 11)

Upper views, unless otherwise stated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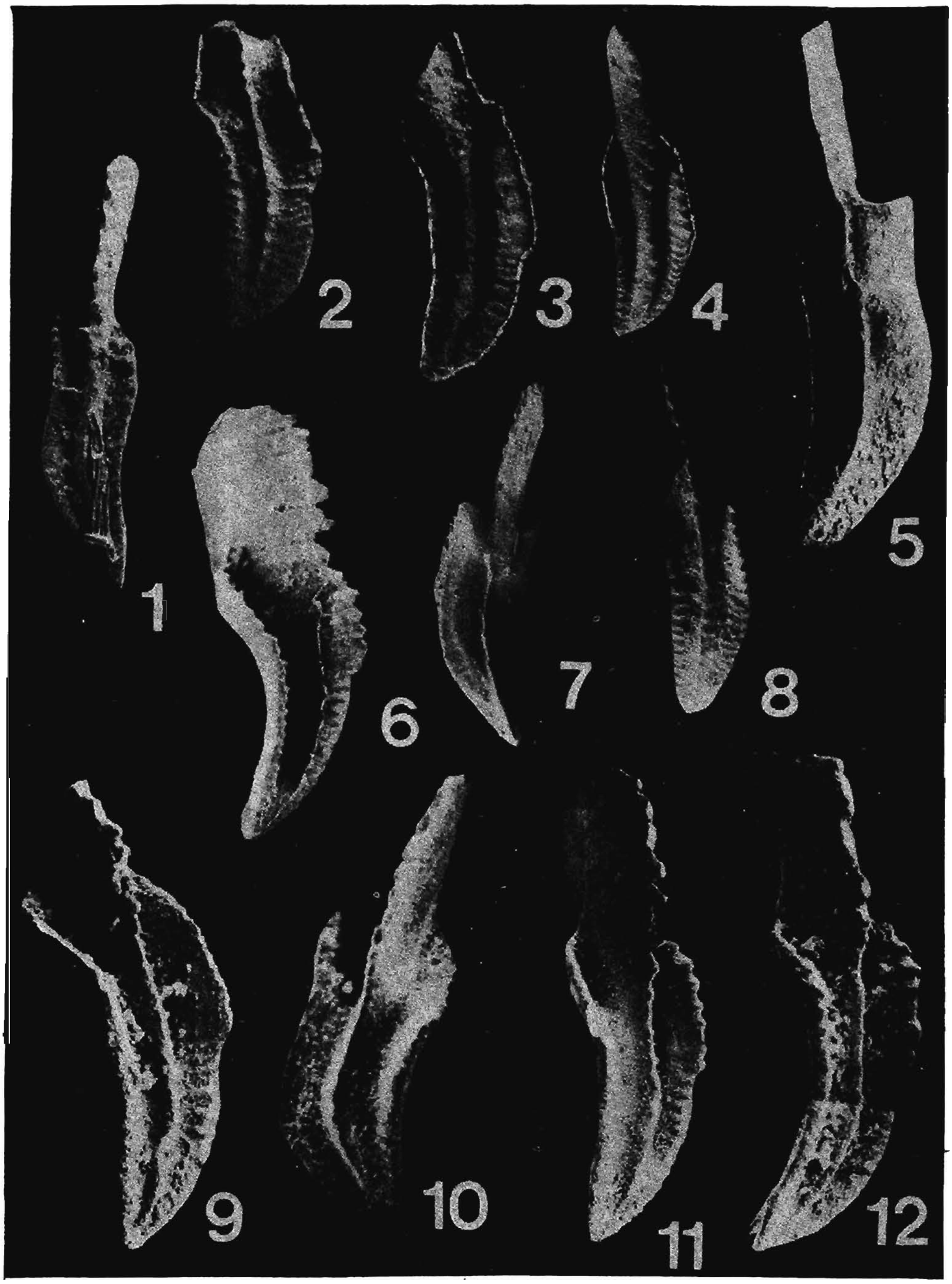
Famennian conodonts of the Lower *marginifera* Zone

1-12 — *Polygnathus limbatus* sp. n.; 1-5 and 7-12 — **paratypes**; 1 — SMF 205 (borehole Chojnice *2*, depth interval 3099-3105 m), × 70; 2-4 — SMF 806, 807, 809 (*ibidem*), × 60; 5 — SMF 439, lower view (*ibidem*), × 75; 6 — **holotype**, SMF 835, lateral view (*ibidem*), × 90; 7 — SMF 803, lower view (*ibidem*), × 60; 8 — SMF 804 (*ibidem*), × 60; 9 — SMF 125 (*ibidem*), × 94; 10-12 — SMF 836, 437, 438 (*ibidem*), × 100

Upper views, unless otherwise stated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Famennian conodonts of the Lower *marginifera* Zone (Figs 1-2, 5-7 and 10) and Lower — Uppermost *marginifera* Zones (Figs 3-4, 8-9 and 11)

1-2 — *Alternognathus pseudostrigosus* Dreesen & Dusar, 1974; 1 — SMF 129, a juvenile specimen with well developed platform (borehole Chojnice *2*, depth interval 3129-3136 m), × 94; 2 — SMF 123, lateral (a) and upper (b) views of specimen with incipient asymmmetrical platform (*ibidem*, 3093-3099 m), × 60; re-illustrated (2b) from Matyja (1987, Pl. 22.2, Fig. 7)

3 — *Polygnathus szulczewskii* Matyja, 1974; SMF 796 (Białogard *8*, 3698-3699 m), × 55

4 — *Polygnathus lauriformis* Dreesen & Dusar, 1974; SMF 757 (*ibidem*), × 60

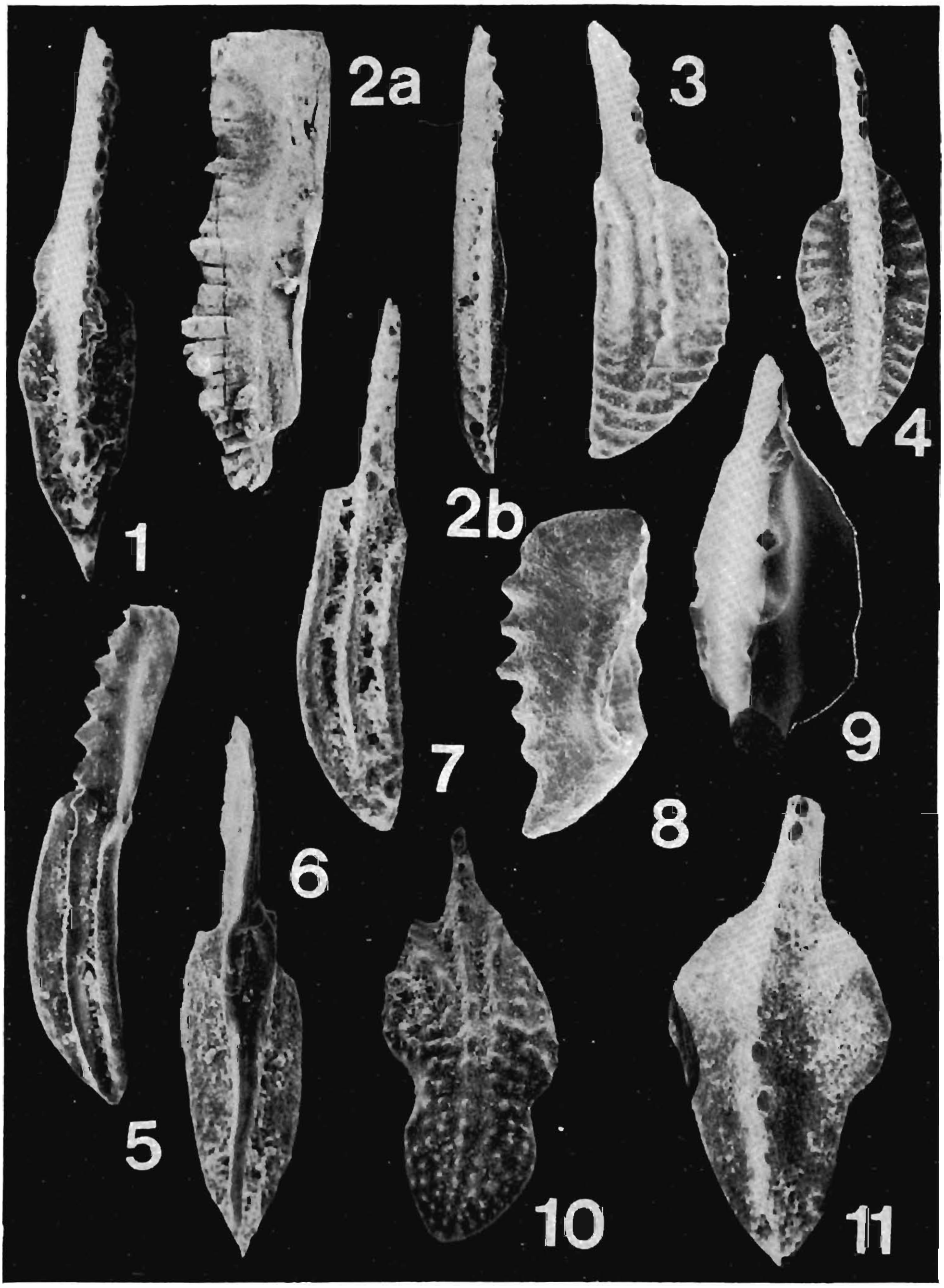
5-7 — *Polygnathus pomeranicus* sp. n., narrow morphotype; 5 — **holotype**, SMF 133 (Chojnice *2*, 3117-3123 m), × 94; re-illustrated from Matyja (1987, Pl. 22.2, Fig. 5); 6 — **paratype**, SMF 161, lower view (Karlino *1*, 4043-4052 m), × 94; 7 — **paratype**, SMF 134 (Chojnice *2*, 3123-3129 m), × 94

8-9 — *Pelekysgnathus inclinatus* Thomas, 1949; 8 — SMF 799, lateral view (Karcino *1*, 2994-2995 m), × 65; 9 — SMF 159 Kłanino *1*, 3251-3252 m), × 60

10 — *Polygnathus triphyllatus* (Ziegler, 1960); SMF 160 (Karlino *1*, 4043-4052 m), × 60; re-illustrated from Matyja (1987, Pl. 22.2, Fig. 8)

11 — *Polygnathus glaber bilobatus* Ziegler, 1962; SMF 140 (Bielica *2*, 3794-3795 m), × 94; re-illustrated from Matyja (1987, Pl. 22.3, Fig. 6)

Upper views, unless otherwise stated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Famennian conodonts of the Upper — Uppermost *marginifera* Zones

1-3 — *Polygnathus pomeranicus* sp. n., wide morphotype with delicate serration of anterior margins; **paratypes**; 1-2 — SMF 790, 802 (borehole Człuchów *IG-1*, depth interval 3223-3224 m), × 80; 3 — SMF 789 (*ibidem*), × 100

4 — *Palmatolepis glabra lepta* ZIEGLER & HUDDLE, 1969; SMF 205 (Unisław *2*, 4474-4475 m), × 48

5 — *Scaphignathus velifer velifer* HELMS, 1959; 5a — SMF 98, lower view, 5b — SMF 57, (Koczała *1*, 2171-2172 m), × 60

6-7 — "*Icriodus*" chojnicensis MATYJA, 1972; SMF 4, 14 (Gorzysław *8*, 3470.2-3470.3 m), × 90; re-illustrated from MATYJA (1987, Pl. 22.3, Figs 1-2)

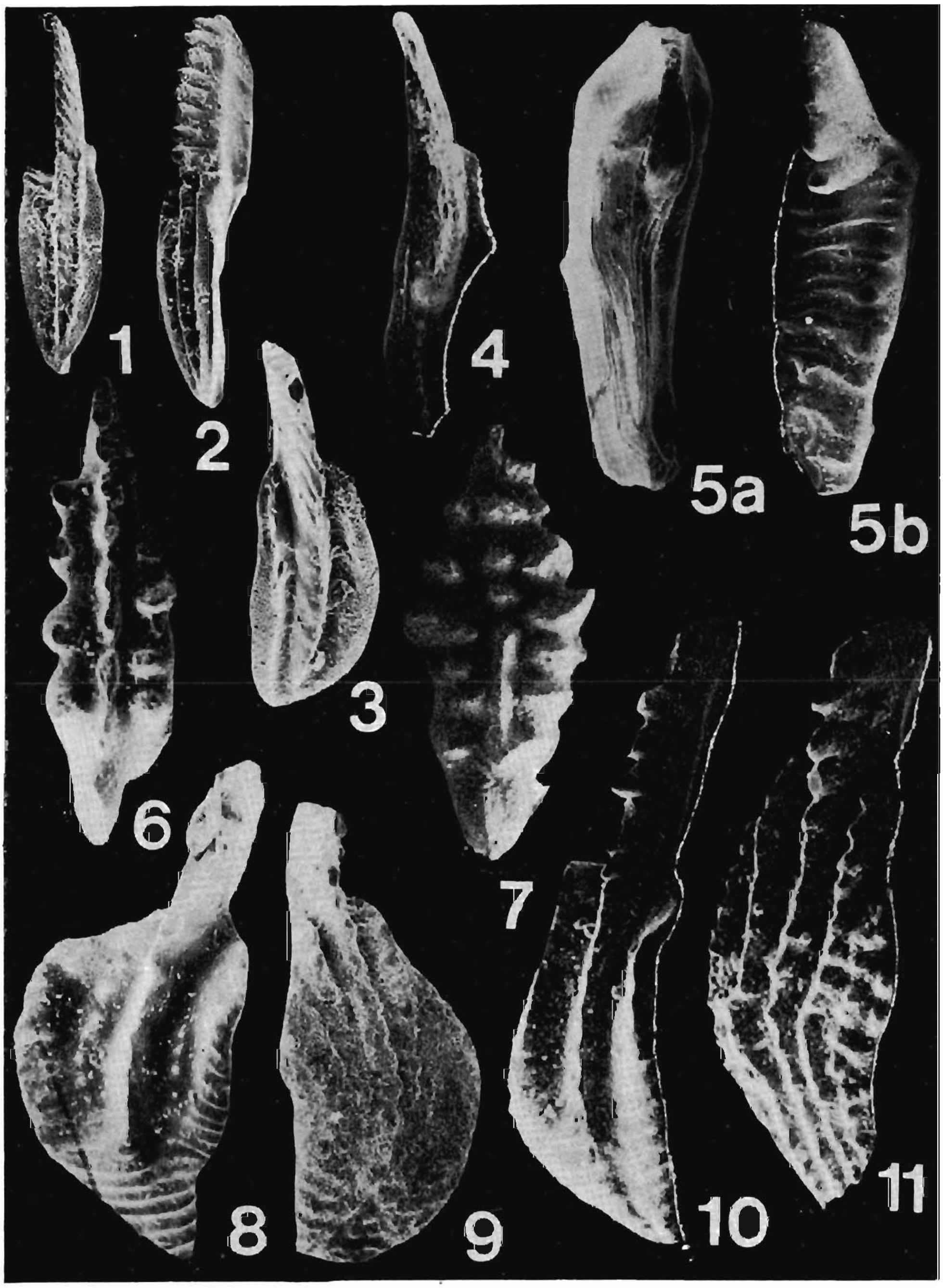
8 — *Polygnathus semicostatus* BRANSON & MEHL, 1934; SMF 119 (Chojnice *4*, 3001-3010 m), × 40; re-illustrated from MATYJA (1987, Pl. 22.2, Fig. 4)

9 — *Polygnathus bouckaerti* DREESEN & DUSAR, 1974; SMF 116 (*ibidem*, 3061-3066 m), × 60

10 — *Polygnathus szulczewskii* MATYJA, 1974; SMF 10 (Gorzysław *8*, 3470.2-3470.3 m), × 90; re-illustrated from MATYJA (1987, Pl.22.3, Fig. 9)

11 — *Polygnathus perplexus* THOMAS, 1949; SMF 8 (*ibidem*), × 90; re-illustrated from MATYJA (1987, Pl. 22.3, Fig. 10)

Upper views, unless otherwise stated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Famennnian conodonts of the Upper *postera* or/and Lower *expansa* Zones

1 — *Polygnathus bouckaerti* Dreesen & Dusar, 1974; SMF 51 (borehole Krojanty *1*, depth interval 2984-2985 m), × 60

2 — *Branmehla inornata* (Branson & Mehl, 1934); SMF 184, lateral view (*ibidem*, 2957-2961 m), × 94

3 — "*Pandorinellina* cf. *insita*" sensu Sandberg & Ziegler, 1979; 3a — SMF 46, lateral view, 3b — SMF 185 (*ibidem*, 2925-2927 m), × 90, × 94

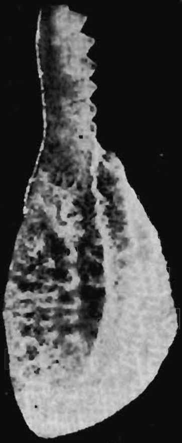
4 — *Pelekysgnathus inclinatus* Thomas, 1949; SMF 47, lateral view (*ibidem*, 2945-2947 m), × 90

5 — *Polygnathus semicostatus* Branson & Mehl, 1934; SMF 52 (*ibidem*, 3002-3004 m), × 60

6 — *Scaphignathus peterseni* Sandberg & Ziegler, 1979; SMF 1 (Gorzysław *8*, 3428-3429 m), × 90; re-illustrated from Matyja (1987, Pl. 22.4, Fig. 9)

7-8 — "*Icriodus*" *raymondi* Sandberg & Ziegler, 1979; 7-8 — SMF 3, 2, gerontic specimens (*ibidem*, 3429-3430 m), × 90; re-illustrated from Matyja (1987, Pl. 22.4, Figs 7 and 8)

Upper views, unless otherwise stated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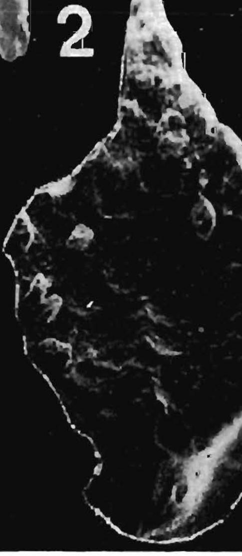
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Famennian conodonts of the Lower *expansa* Zone

1 — *Polygnathus semicostatus* BRANSON & MEHL, 1934; SMF 92 (borehole Koczała *1*, depth interval 2166-2171 m), × 60; re-illustrated from MATYJA (1987, Pl. 22.4, Fig. 2)

2 — *Polygnathus szulczewskii* MATYJA, 1974; SMF 93 (*ibidem*), × 60; re-illustrated from MATYJA (1987, Pl. 22.4, Fig. 1)

3-5 — *Clydagnathus ormistoni* BEINERT, KLAPPER, SANDBERG & ZIEGLER, 1971; 3 — SMF 101 (*ibidem*, 2171-2172 m), × 94; 4 — SMF 55, lower view (*ibidem*), × 90; 5a — SMF 58, 5b — SMF 100, lower view (*ibidem*), × 90, × 94; re-illustrated from MATYJA (1987, Pl. 22.5, Figs 3, 1b and 4)

6 — *Scaphignathus ziegleri* DRUCE, 1969; 6a — SMF 56, 6b — SMF 99, lower view (*ibidem*), × 94; re-illustrated from MATYJA (1987, Pl. 22.5, Figs 6 and 5)

Upper views, unless otherwise stated


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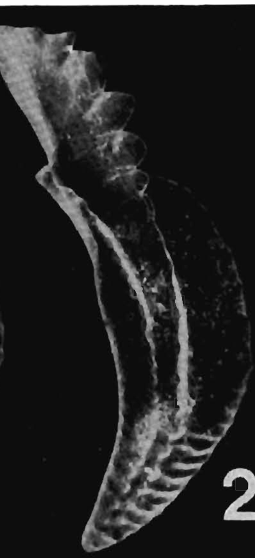
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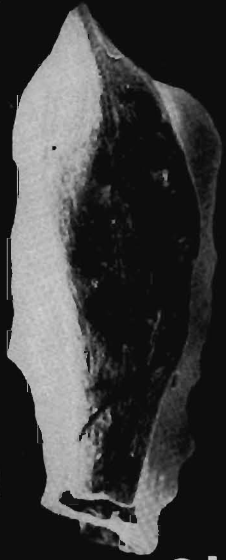
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Famennian conodonts of the Lower *expansa* Zone

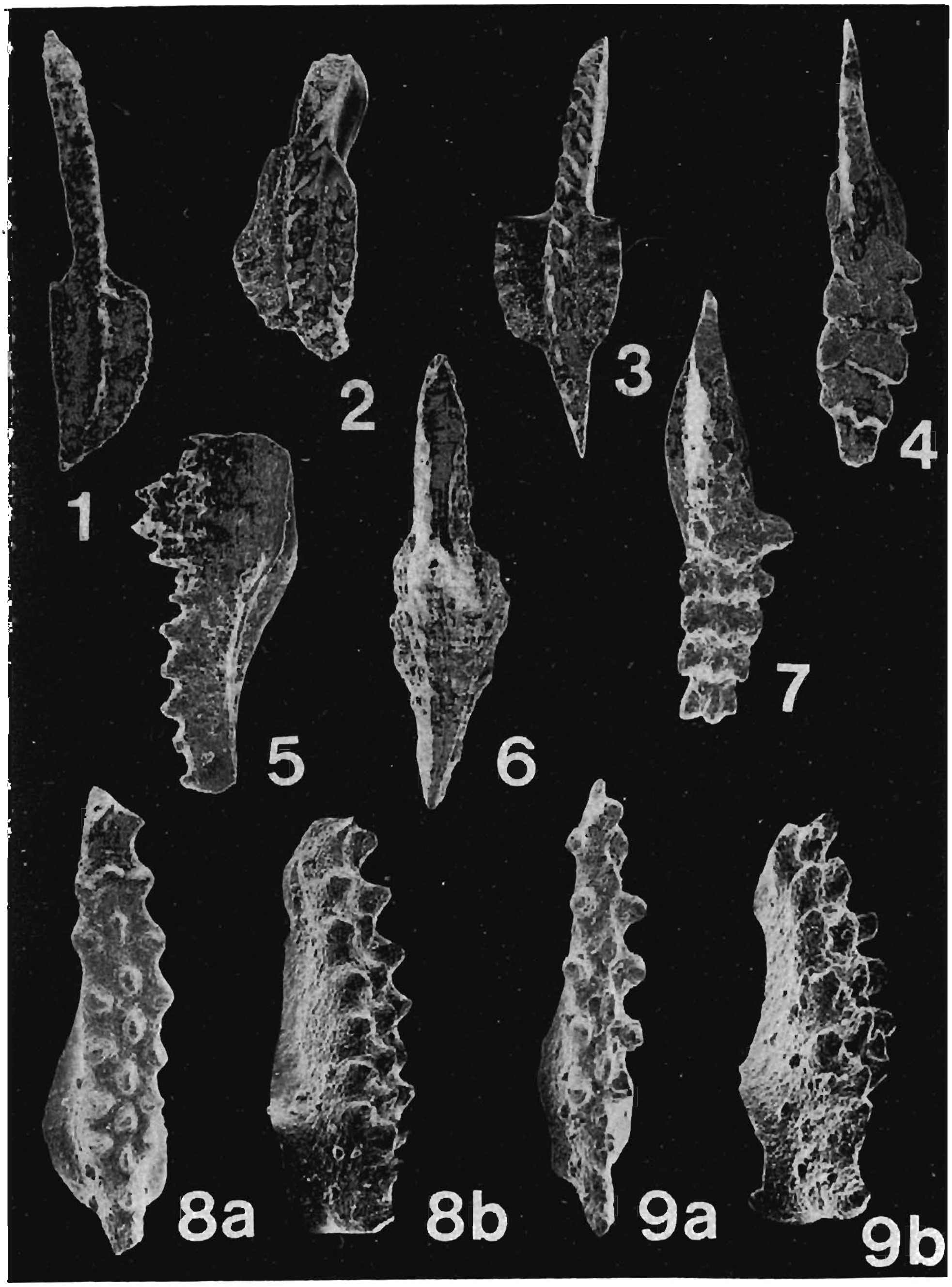
1 — *Polygnathus delicatulus* Ulrich & Bassler, 1926; SMF 779 (borehole Człuchów *IG-1*, depth interval 2928-2929 m), × 100

2-3 — *Polygnathus streeli* Dreesen, Dusar & Groessens, 1976; 2 — SMF 771, juvenile specimen (*ibidem*, 2882-2883 m), × 140; 3 — SMF 778 (*ibidem*, 2918-2919 m), × 65

4-7 — *Alternognathus costatiformis* sp. n.; 4 — **holotype**, SMF 789 (*ibidem*, 2996-2997 m), × 90; 5-7 — **paratypes**; 5 — SMF 787, lateral view (*ibidem*), × 100; 6 — SMF 788, lower view (*ibidem*), × 140; 7 — SMF 785 (*ibidem*), × 110

8-9 — "*Icriodus*" *raymondi* Sandberg & Ziegler, 1979; 8 — SMF 783, upper (a) and lateral (b) views (*ibidem*), × 80; 9 — SMF 784, upper (a) and lateral (b) views (*ibidem*), × 120

Upper views, unless otherwise stated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Famennian conodonts of the Lower *expansa* Zone

* All with the except of *Polygnathus* cf. *glaber bilobatus* which is redeposited from the Upper or Uppermost *marginifera* Zone

1 — *Branmehla* sp.; SMF 781, lateral view (borehole Człuchów *IG-1*, depth interval 2932-2933 m), × 80

2 — *Bispathodus stabilis* (Branson & Mehl, 1934), morphotype 1; SMF 771 (*ibidem*, 2915-2916 m), × 70

3-4 — *Polygnathus semicostatus* Branson & Mehl, 1934; 3 — SMF 774 (*ibidem*, 2900-2901 m), × 60; 4 — SMF 722 (*ibidem*), × 80

5* — *Polygnathus* cf. *glaber bilobatus* Ziegler, 1962; SMF 780, juvenile specimen (*ibidem*, 2932-2933 m), × 160

6 — *Polygnathus subirregularis* Sandberg & Ziegler, 1979; SMF 769 (*ibidem*, 2882-2883 m), × 30

7 — *Polygnathus szulczewskii* Matyja, 1974; SMF 782 (*ibidem*, 2996-2997 m), × 60

8-10 — *Polygnathus experplexus* Sandberg & Ziegler, 1979; 8 — SMF 770 (*ibidem*, 2882-2883 m), × 50; 9 — SMF 776 (*ibidem*, 2914-2915 m), × 35; 10 — SMF 773 (*ibidem*, 2901-2902 m), × 60

All upper views, unless otherwise stated


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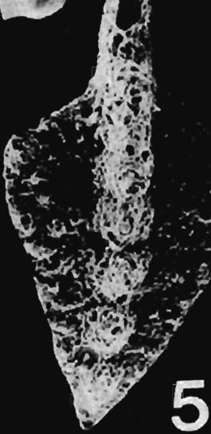
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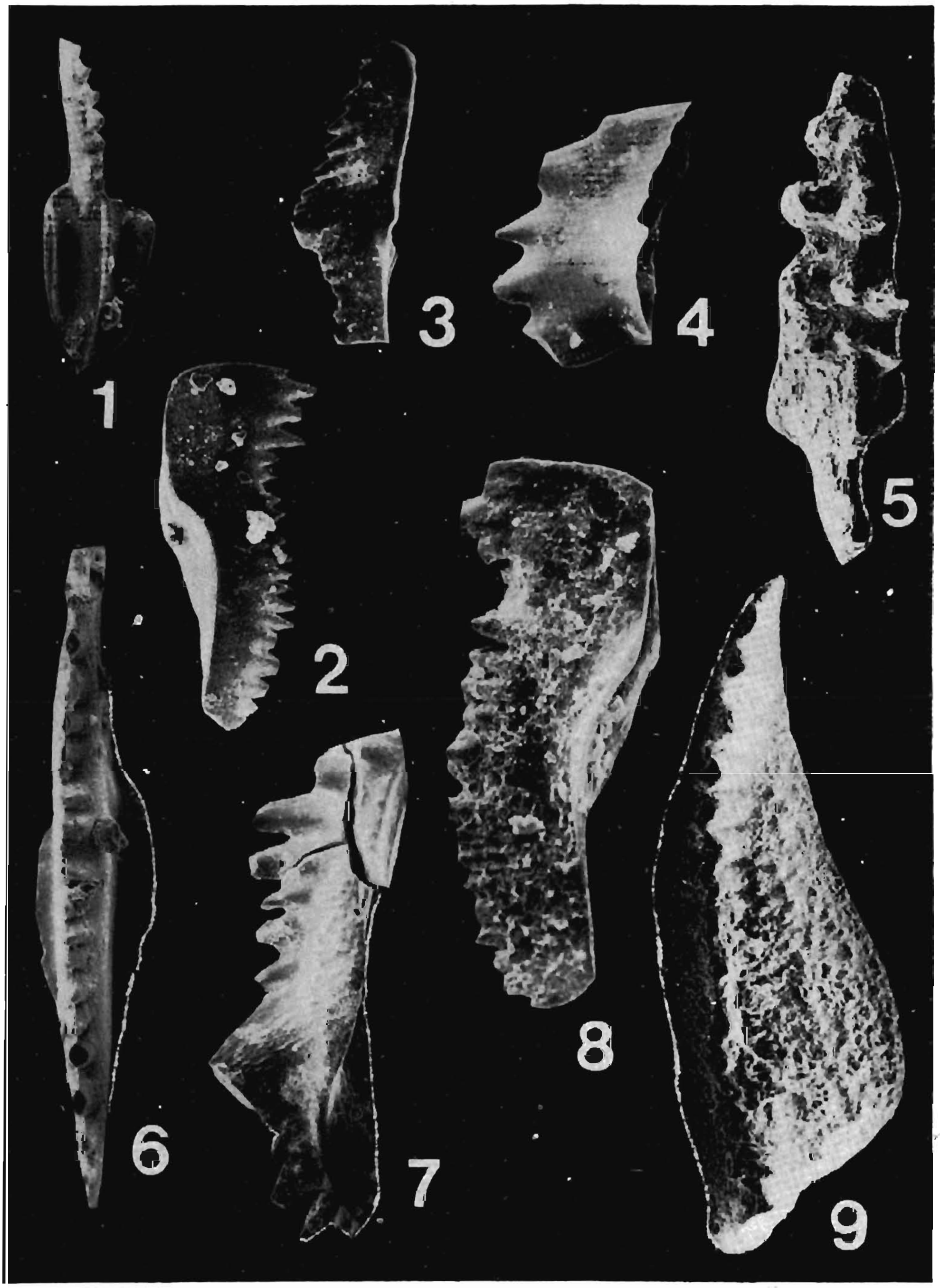
Famennian conodonts of the Lower *expansa* Zone (Figs 1, 3-4) and Middle *expansa* Zone (Figs 2, 5-9)

1 — *Polygnathus communis communis* BRANSON & MEHL, 1934; SMF 149 (borehole Karcino *2*, depth interval 2900-2901 m), × 94; re-illustrated from MATYJA (1987, Pl. 22.4, Fig. 5)
2 — *Mehlina strigosa* (BRANSON & MEHL, 1934); SMF 41, lateral view (Krojanty *1*, 2655-2660 m), × 60; re-illustrated from MATYJA (1987, Pl. 22.6, Fig. 2)
3 — *Branmehla bohlenana* (HELMS, 1959); SMF 148, lateral view (Karcino *2*, 2900-2901 m), × 94
4 — *Pelekysgnathus inclinatus* THOMAS, 1949; SMF 150, lateral view (*ibidem*), × 94; re-illustrated from MATYJA (1987, Pl. 22.4, Fig. 6)
5 — "*Icriodus*" *costatus darbyensis* KLAPPER, 1958, morphotype 2; SMF 25 (Gorzysław *9*, 3250-3251 m), × 90
6 — *Bispathodus stabilis* (BRANSON & MEHL, 1934), morphotype 1; SMF 145 (Krojanty *1*, 2655-2660 m), × 94; re-illustrated from MATYJA (1987, Pl. 22.6, Fig. 11)
7 — *Polygnathellus giganteus* THOMAS, 1949; SMF 146 (*ibidem*), × 60
8 — "*Pandorinellina* cf. *insita*" sensu SANDBERG & ZIEGLER, 1979; SMF 144 (*ibidem*, 2650-2655 m), × 94
9 — *Hemilistrona pulchra* CHAUFF & DOMBROWSKI, 1977; SMF 39 (*ibidem*), × 90

Figs 2-4, 7-8 lateral views; 1, 5-6, 9 upper views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Famennian conodonts of the ?Middle *expansa* Zone (Figs 1-2, 4) and Upper *expansa* — Lower *praesulcata* Zones (Figs 3, 5-10)

1 — *Polygnathus delicatulus* Ulrich & Bassler, 1926; SMF 109 (borehole Babilon *1*, depth interval 3207-3214 m), × 94; re-illustrated from Matyja (1987, Pl. 22.6, Fig. 1)

2 — *Bispathodus aculeatus anteposicornis* (Scott, 1961), SMF 108, lateral view (*ibidem*), × 40; re-illustrated from Matyja (1987, Pl. 22.6, Fig. 4)

3 — *Siphonodella praesulcata* Sandberg, 1972; 3a — SMF 152, lower view; re-illustrated from Matyja (1987, Pl. 22.6, Fig. 6), 3b — SMF 803 (Karsina *1*, 2701-2705 m), × 94, × 180

4 — *Mehlina strigosa* (Branson & Mehl, 1934); SMF 102, lateral view (Babilon *1*, 3121-3126 m), × 94; re-illustrated from Matyja (1987, Pl. 22.6, Fig. 3)

5 — *Pandorinellina plumula* (Rhodes, Austin & Druce, 1969); SMF 106, lateral view (*ibidem*, 2949-2956 m), × 90; re-illustrated from Matyja (1987, Pl.22.6, Fig. 5)

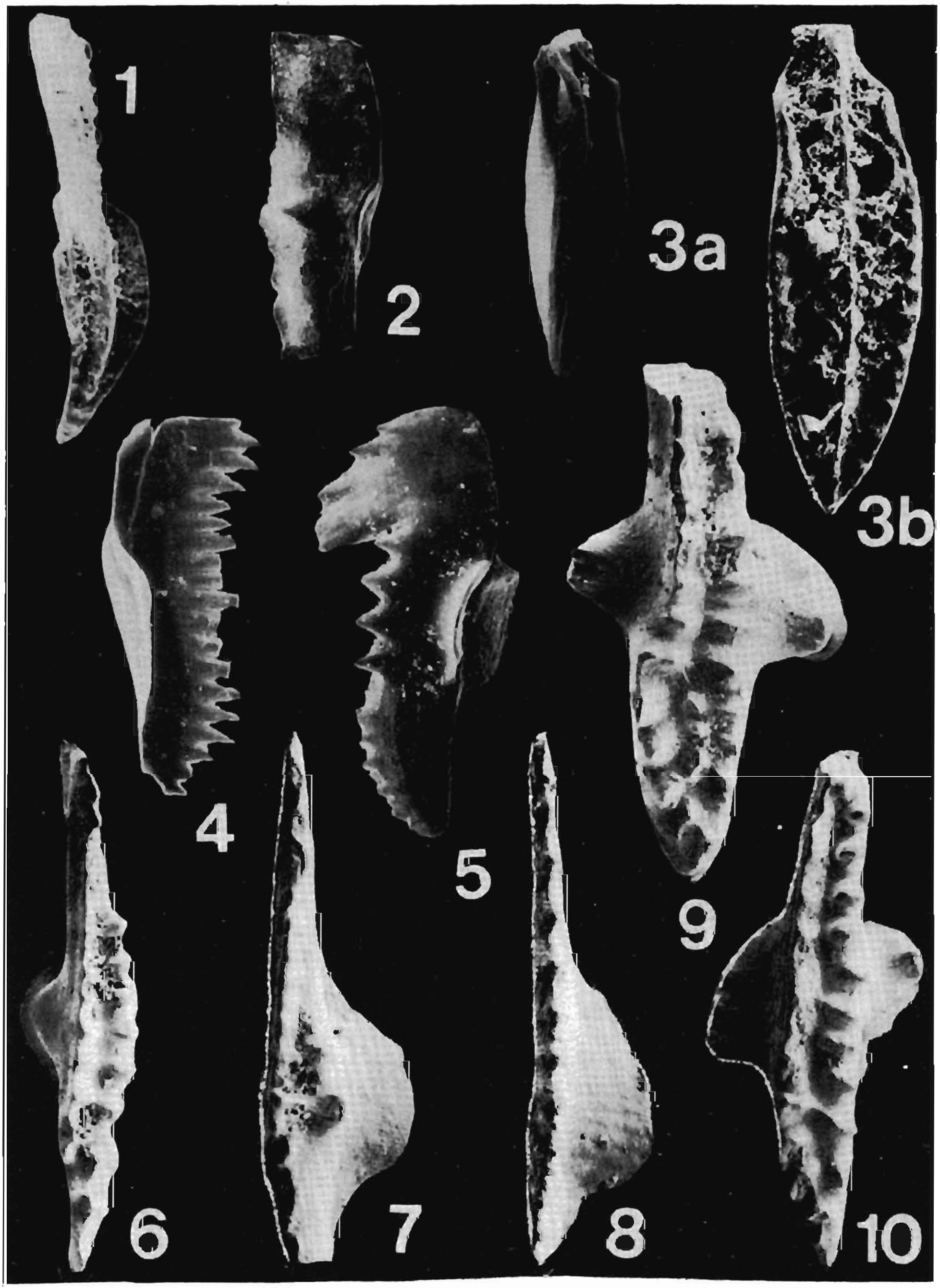
6 — *Bispathodus costatus* (Branson, 1934), morphotype 2; SMF 677 (Rzeczenica *1*, 2999-3003 m), × 55

7 — *Bispathodus aculeatus aculeatus* (Branson & Mehl, 1934); SMF 681 (*ibidem*), × 100

8 — *Branmehla suprema* (Ziegler, 1962); SMF 671 (*ibidem*, 2924-2925 m), × 130

9-10 — *Bispathodus ultimus* (Bischoff, 1957), morphotype 2; 9 — SMF 678, right Pa element (*ibidem*, 2999-3003 m), × 60; 10 — SMF 679, left Pa element (*ibidem*), × 55

Upper views, unless otherwise stated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STAGES	NEARSHORE CONODONT ZONATION		STANDARD CONODONT ZONATION (pelagic biofacies)		STANDARD ENTOMOZOACEAN ZONATION		POMERANIAN PALYNOLOGICAL ZONATION	
IVORIAN	LOCAL CONODONT ZONATIONS		↑ anchoralis-latus ↑		UNZONED		claytoni	U
			typicus	U				M
				L				L
HASTARIAN			isosticha-U.crenulata				major	
			L.crenulata					
			sandbergi		latior			
			duplicata	U			NOT FOUND	
				L				
			sulcata					
FAMENNIAN	"Icriodus" costatus	U	praesulcata	U	hemisphaerica / latior Int.			
				M				
				L			rarituberculata	
			expansa	U	hemisphaerica -dichotoma	U	lupata versabilis	
		M		M				
		L		L		L	cornuta	
			postera	U				
				L	intercostata		NOT STUDIED	
			trachytera	U				
				L				
			marginifera	UM				
	"Icriodus" cornutus	U		U	serratostriata -nehdensis	U	ordinarius	
				L		L		
			rhomboidea	U				
		M		L				
			crepida	UM				
				U				
				M				
				L	sigmoidale			
		L	triangularis	U				
				M			NOT STUDIED	
				L				
FRASNIAN	Pelekysgnathus planus	U	linguiformis		sartenaeri			
			rhenana	U	cica./barrandei Int.			
		L		L	cicatricosa			
	Icriodus symmetricus		jamieae					
			hassi	U				
				L			optivus -triangulatus	U
			punctata		cicatricosa / torleyi Int.			
			transitans					M
	UNZONED		falsiovalis	U	torleyi			
				L				

Fig. 5. Correlation chart of the Upper Devonian and Lower Carboniferous standard conodont zonation (*after* SANDBERG, W. ZIEGLER, LEUTERITZ & BRILL 1978; LANE, SANDBERG & W. ZIEGLER 1980; SANDBERG & DREESEN 1984; W. ZIEGLER & SANDBERG 1990), standard entomozoacean (GROSS-UFFENORDE 1990) and Pomeranian palynological zonations (TURNAU 1979, MATYJA & TURNAU 1989, CLAYTON & TURNAU 1990) discussed in the text

The correlation of this zonation with the standard conodont and othe biostratigraphic schemes is recognizable (*see* Text-fig. 5).

The palynological zones in Western Pomerania are of the *Oppel*-zone character, being based on concurrent ranges of selected species and the presence of characteristic assemblages of species. They are not called concurrent-range zones because they are often recognized when not all the diagnostic species are present. The Famennian zones are defined basing on both spore and acritarch species because the latter are an important component of the assemblages. All zones and subzones of Lower Carboniferous are defined on the first appearance of one or several taxa, thus they are readily distinguishable one from another when rich and well preserved assemblages are available.

GENERAL REMARKS ON CONODONT ZONATION

The standard Upper Devonian conodont zonation, originally proposed by ZIEGLER (1962) and completely revised during the last three decades (*see* ZIEGLER & SANDBERG 1990) is now based mainly on taxa that were distinguished globally in the pelagic realm.

The standard zones are named mainly after species or subspecies of the pelagic genera *Mesotaxis* at the beginning of the Frasnian, *Palmatolepis* during most of the Frasnian and Famennian, and *Siphonodella* at the end of the Famennian.

The start of each of the conodont zones is defined by the first occurrence of a diagnostic species or subspecies, and the upper limit is defined by the first occurrence of another diagnostic species or subspecies, preferably the next phyletically younger taxon (ZIEGLER & SANDBERG 1990). The conodont faunas of each zone are characterized by a distinctive association of conodont elements which includes the diagnostic taxon defining the base of the zone. Despite the absence of the diagnostic taxon a zone can be recognized by the remaining fauna, and zonal limits can be approximately defined by overlaps in ranges of taxa within the successive faunas. This zonation has proven useful in pelagic and hemipelagic facies of tropical and subtropical areas and has thus become the worldwide standard zonation for Upper Devonian biostratigraphy. The pelagic affinity of the genera *Mesotaxis*, *Palmatolepis* and *Siphonodella*, however, is a major problem in recognizing the standard conodont zones within extensive shallow-marine and nearshore to restricted marine environments. In such areas the standard conodont zonation is somewhat difficult and locally even impossible to apply.

Therefore, SANDBERG & DREESEN (1984) have proposed an alternative zonation based on shallow water taxa, mainly on "*Icriodus*" and *Pelekysgnathus*, for local intrabasin correlation. The Late Devonian nearshore conodont zonation comprises 9 zones compared to the 32 zones of the standard zonation for the same time interval (*see* Text-fig. 5). Like the *Palmatolepis*-based standard zonation, the nearshore icriodontid-based zonation comprises zones defined on the basis of first occurrences of diagnostic species but containing also faunal associations that permit recognition of the zones even from faunas that lack the zonal name giver.

In conclusion, the standard conodont zonation is more applicable to the offshore, pelagic conodont biofacies, whereas the shallow-water icriodontid zonation is more applicable to the nearshore conodont biofacies, as suggested by SANDBERG & DREESEN (1984). The proposed icriodid-zonation is applicable to a shallow-water carbonate environments of the Famennian deposits of the western United States as well as to a totally different sedimentary regime of the Famennian of Belgium in which coarse clastic rocks predominate over carbonate rocks.

Unfortunately, in shallow settings such as the late Famennian Pomeranian shelf, a few shallow-water species of the genus *Polygnathus* dominate the faunas, and the key representatives of the genera "*Icriodus*" and *Pelekysgnathus* occur in small numbers. Therefore, applying the icriodid zonation, such as that proposed for the western United States and southern Belgium, to the upper Famennian sequences on the Pomeranian shelf might increase the possibility of misdating.

In Western Pomerania the presence of standard conodont zones from the Frasnian *punctata* Zone up to the Famennian Lower (or lowermost Middle) *praesulcata* Zone has been documented.

Fortunately, there were no important restrictions in the use of the Upper Devonian standard conodont zonations for nearly the whole Frasnian and a big part of the Famennian, up to the *marginifera* Zone in Western Pomerania. The last palmatolepids, which are the basis for the Late Devonian standard zonation, definitively retreat from the Pomeranian shelf at the end of the *marginifera* Chron owing to ecological reasons. The younger *trachytera* and *postera* Zones have not been found in Western Pomerania. The Lower and Middle *expansa* Zones were easily recognizable owing to the presence of numerous bizzare forms characteristic of extremely shallow environments. Their ranges have been correlated with the standard zonation given by SANDBERG & ZIEGLER (1979). The Upper *expansa* and Lower *praesulcata* Zones were also recognizable owing to the presence of numerous species of *Bispathodus*. The younger Late Devonian conodont zones (Middle and Upper *praesulcata*) have not been found in Western Pomerania.

An application of original zone definitions based on index taxa was not possible in most cases in the studied area. Therefore, ranges of accompanying taxa correlated with the standard conodont zonation (*see* ZIEGLER 1971; SANDBERG & ZIEGLER 1973; KLAPPER & ZIEGLER 1979; SANDBERG & ZIEGLER 1979; SANDBERG & DREESEN 1984; ZIEGLER & SANDBERG 1984b; SANDBERG & *al.* 1988b; SANDBERG & *al.* 1989; ZIEGLER & SANDBERG 1990; SANDBERG & *al.* 1992) have been usually employed according to ZIEGLER & SANDBERG (1990) recommendation. Some of zones have not been recognized and the age of some samples has been only widely determined to be equivalents of 2-3 zones, due to several reasons of which the most important were: (*i*) great thickness of Upper Devonian sediments resulting in reducing of conodont frequency which, in turn, is the cause of relatively poor collection lacking of many index species; (*ii*) incompleteness of coring; (*iii*) unfavorable environmental conditions for conodonts, especially in the earliest Frasnian and latest Famennian.

The conodonts distribution and their frequency in particular sections are presented in Tables 1-14.

FRASNIAN CONODONT ZONES

The lowermost Frasnian *falsiovalis* and *transitans* Zones (*see* Text-fig. 5) have not been recognized in Western Pomerania, probably owing to ecological reasons, although the possibility of their presence cannot be precluded. The lowermost Frasnian is developed here in siliciclastic facies (the Wyszebórz and Chojnice formations) which are particularly poor in organic remains, especially in conodonts, thus the biostratigraphic studies were impossible. These deposits contain rare representatives of *Icriodus subterminus* and *Polygnathus* sp., as well as some corals (NOWIŃSKI & PREJBISZ 1986).

The earliest abundant conodont fauna in Western Pomerania is that of the *punctata* Zone, recorded in the basal parts of the Strzeżewo Member of the Człuchów Formation and in the Koczała Formation (*see* Text-fig. 4). The *punctata* Zone is recognized here thanks to overlaps of the ranges of *Ancyrodella gigas* and *Ad. rotundiloba*. The common association is composed of *Icriodus subterminus, I. symmetricus, Mesotaxis asymmetrica, Polygnathus alatus, Pol. pacificus,* and *Pol. ?webbi* (Text-fig. 6, Tables 4-5 and Pl. 17, Figs 1-6). In the basal part of the Strzeżewo Member of the Gosław-*1* section, the presence of entomozoacean ostracode *Ungerella calcarata* is noted (ŻBIKOWSKA 1992) as well as miospores of the local Upper *optivus-triangulatus* (OT3) Zone (TURNAU, *in preparation*; *see* Text-figs 4 and 5 for correlation).

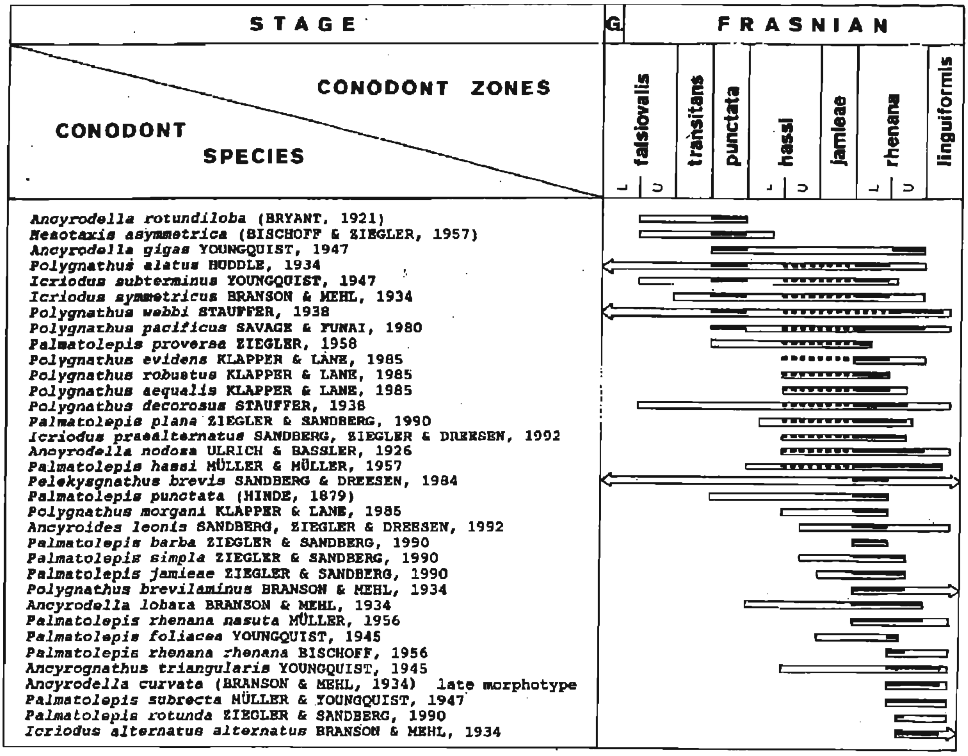

Fig. 6. Range chart of the Frasnian conodonts in Western Pomerania

Solid bars indicate certain recognition of the zone, dashed bars indicate uncertain recognition of the zone in comparison with total ranges (*empty bars*); schemes *after* SANDBERG & DREESEN (1984); KLAPPER & LANE (1985); SANDBERG, W. ZIEGLER, DREESEN & BUTLER (1988); W. ZIEGLER & SANDBERG (1990); BELKA & WENDT (1992) and SANDBERG, W. ZIEGLER, DREESEN & BUTLER (1992)

It is difficult to separate the *hassi* from the *jamieae* Zone and sometimes from the Lower *rhenana* Zone throught the area due to the lack of many diagnostic species in the studied material. Unfortunately, these zones are dominated (*see* Text-fig. 6; Tables 1, 6, 13-14; Pl. 18) by long-ranging species of the genus *Polygnathus* (viz. *Pol. aequalis, Pol. alatus, Pol. decorosus, Pol. evidens, Pol. pacificus, Pol. robustus,* and *Pol. webbi*), *Icriodus* (viz. *I. subterminus,* and *I. symmetricus*), and *Palmatolepis* (viz. *Pal. hassi, Pal. plana,* and *Pal. proversa*).

The Lower *rhenana* Zone may be distinguished on the basis of the co-occurrence of *Palmatolepis barba* whose known range is restricted to the Lower *rhenana* Zone, and *Pal. simpla, Pal. proversa, Pal. punctata,* and *Pal. rhenana nasuta,* as well as *Icriodus subterminus* and many polygnathids (*see* Text-fig 6, Tables 13-14 and Pls 19-20).

The Upper *rhenana* Zone is characterized by the co-occurrence of many species of *Ancyrodella, Palmatolepis,* and *Icriodus.* The highest range of *Ancyrodella gigas, Icriodus praealternatus, Palmatolepis simpla, Pal. jamieae and Pal. foliacea* was within the Upper *rhenana* Zone, whereas *Palmatolepis rhenana rhenana, Pal. subrecta, Pal. rotunda, Ancyrodella curvata* late morphotype and *Icriodus alternatus alternatus* first occurred in this zone (*see* Text-fig. 6, Tables 1, 14 and Pls 21-22).

Table 1

Distribution and frequency of the Frasnian and Famennian platform conodonts in the Strzeżewo *1*, Gorzysław *8* and Gorzysław *11* sections; *see* Text-fig. 3 for full names of the conodont zones; reworked conodonts are asterisked

CONODONT ZONES	HA$_2$–RH$_1$			RH$_2$						CR$_2$		MR$_1$–$_3$			PO$_2$/MK$_1$		MK$_1$–$_2$	
[1] Strzeżewo *1* [4] Gorzysław *8* [7] Gorzysław *11* depth [m]	[7]	[1]				[4]												
Conodonts	3228–3211	4360–4356	4300–4290	4109–4104	4098–4088	3832–3830	3802–3800	3767–3764	3737–3735	3602–3599	3564–3562	3470.8–3470.7	3470.5–3470.3	3470.3–3470.2	3430–3429	3429–3328	3362–3361	3315–3314
Icriodus symmetricus	6																	
Polygnathus alatus			1															
Polygnathus decorosus	2	1					2											
Polygnathus pacificus		1	1	1														
Polygnathus webbi	11				1													
Palmatolepis plana	6																	
Icriodus praealternatus						1		1	1									
Ancyrodella lobata				1			1											
Ancyrognathus triangularis				1														
Polygnathus brevilaminus						1												
Palmatolepis hassi				1														
Palmatolepis jamieae				2														
Palmatolepis rhenana nasuta							2											
Palmatolepis rhenana rhenana							4											
Palmatolepis rotunda							1											
Palmatolepis subrecta				1														
Polygnathus communis communis											1		4	9				
Palmatolepis circularis										1								
"*Icriodus*" *chojnicensis*													4	4				
Pelekysgnathus iclinatus														1				
Polygnathus glaber bilobatus												1						
Polygnathus glaber glaber														2				
Polygnathus limbatus													1					
Polygnathus perplexus													1	3				
Polygnathus pomeranicus													12	9				
Polygnathus rhomboideus														*1				
Polygnathus semicostatus														2	1			
Polygnathus szulczewskii													1	3				
"*Icriodus*" *raymondi*															2			
"*Pandorinellina cf. insita*"																1		
Scaphignathus peterseni																1		
"*Icriodus*" *costatus darbyensis* morph. 2																	1	
Bispathodus aculeatus aculeatus																		3

Table 2

Distribution and frequency of the Frasnian, Famennian and Tournaisian platform conodonts in the Gorzysław *9*, Gorzysław *14*, Karcino *1*, Karcino *2* and Białogard *8* sections; *see* Text-fig. 3 for full names of the conodont zones

CONODONT ZONES	TI$_3$		TI$_3$ – CR	CR$_{2-3}$		EX$_1$	PR$_1$	MR$_{1-3}$			EX$_2$		EX$_3$		?		SU7		
	[6]			[10]				[9]	[16]		[5]								
[5] Gorzysław *9* [6] Gorzysław *14* [9] Karcino *1* [10] Karcino *2* [16] Białogard *8* depth [m] Conodonts	2882–2865	2865–2854	2847–2829	2977–2976	2939–2938	2901–2900	2851–2850	2995–2994	3699–3698	3696–3695	3265–3264	3251–3250	3215–3214	3210–3209	3173–3172	3181–3180	3170–3169	3163–3162	3155–3154
Icriodus alternatus alternatus	3	25	1																
Polygnathus brevilaminus	14	2																	
Polygnathus praecursor	3																		
Palmatolepis minuta minuta	4																		
Palmatolepis triangularis	4																		
Palmatolepis triangularis -> -> *Pal. quadrantinodosalobata*		1																	
Polygnathus communis communis				2		1		1			1				1				
Palmatolepis crepida					1														
Palmatolepis wolskajae					1														
Pelekysgnathus inclinatus						1		1											
Polygnathus lauriformis									1										
Polygnathus nodocostatus										1									
Polygnathus pomeranicus								1											
Polygnathus szulczewskii									1										
Polygnathus semicostatus										1									
Palmatolepis marginifera marginifera								1	1	2									
Branmehla bohlenana						1													
"*Icriodus*" *costatus darbyensis* morph. 2												1							
Bispathodus aculeatus aculeatus											1								
Bispathodus costatus morphotype 1													3						
Polygnathus delicatus														1					
Polygnathus streeli														1					
Bispathodus stabilis morphotype 1							1												
Pseudopolygnathus graulichi							1												
Polygnathus inornatus																1			
Polygnathus vogesi																		1	
Siphonodella sulcata																	1	2	1

Table 3

Distribution and frequency of the Frasnian, Famennian and Tournaisian platform conodonts in the Karlino *1*, Kłanino *1* and Karsina *1* sections; *see* Text-fig. 3 for full names of the conodont zones

CONODONT ZONES	CR$_{1-2}$			CR	CR 3-4	PR$_1$	MR$_{2-3}$			CR$_{3-4}$		MR$_1$	EX$_2$	SN-CE$_1$		
	[27]						[26]			[18]						
[18] Karlino *1* [26] Kłanino *1* [27] Karsina *1* depth [m] Conodonts	2875–2873	2842–2840	2814–2812	2787–2784	2756–2752	2705–2701	3305–3304	3286–3285	3252–3251	4175–4166	4119–4112	4052–4043	3889–3887	3642–3641	3635–3632	3616–3614
Polygnathus procerus			1	1						1						
Polygnathus nodocostatus ovatus					2											
Polygnathus cf. *padovanii*					4											
Palmatolepis circularis		1	2													
Palmatolepis crepida		1		1	2											
Palmatolepis minuta wolskae					1											
Palmatolepis quadrantinodosalobata			2	2						1						
Palmatolepis perlobata schindewolfi										1						
Palmatolepis tenuipunctata				1							1					
Palmatolepis wolskajae			1													
Palmatolepis wolskajae Pal. circularis	1															
Polygnathus pomeranicus												1				
Polygnathus semicostatus							1	2	4			5				
Polygnathus szulczewskii												2				
Polygnathus triphyllatus												1				
Pal. quadrantinodosa quadrantinodosa												1				
Pelekysgnathus inclinatus							1		1							
Polygnathus glaber bilobatus									1							
Palmatolepis glabra lepta								1								
Polygnathus communis communis													2	1		
Polygnathus experplexus													1			
Polygnathus streeli													1			
Mehlina strigosa													1			
Bispathodus ultimus morphotype 2						1										
Siphonodella praesulcata						1										
Pseudopolygnathus dentilineatus														1		
Polygnathus inornatus															1	
Siphonodella sulcata														1		
Siphonodella quadruplicata																1

Table 4

Distribution and frequency of the Frasnian platform conodonts in the Jamno *IG-1* section; *see* Text-fig. 3 for full names of the conodont zones

CONODONT ZONES	PU?						PU	?					
[23] Jamno *IG1* Conodonts	1918–1917	1897–1896	1883–1882	1887–1883	1880–1879	1878–1877	1876–1875	1867–1866	1865–1864	1837–1836	1713–1712	1703–1702	1701–1700
Icriodus subterminus	1	1	1		2	1	12	1					1
Ancyrodella gigas							1						
Ancyrodella rotundilobata							1						
Polygnathus aequalis								1					
Polygnathus alatus					2		3	3		1	1		
Polygnathus pacificus	1												
Polygnathus ?webbi	1						1					1	
Polygnathus sp.				1									
Polygnathus spp.	6		3	5			40		2				

Table 5

Distribution and frequency of the Frasnian platform conodonts in the Wyszebórz *1* section; *see* Text-fig. 3 for full names of the conodont zones

CONODONT ZONES	?	TRANSITANS? + PU											PU					?
[24] Wyszebórz *1* depth [m] Conodonts	2387–2386	2357–2356	2287–2286	2163–2162	2096–2095	2093–2092	2055–2054	2052–2051	2024–2023	2023–2022	2021–2020	2014–2013	2013–2012	2009–2008	2005–2004	1998–1997	1940–1939	1937–1936
Icriodus subterminus				2				4										
Icriodus symmetricus		4			1							1						
Icriodus spp.			2	2									1	1		6	6	
Ancyrodella gigas													1			6		
Ancyrodella rotundiloba													1	2			1	
Ancyrodella spp.								1					1			8	2	
Polygnathus spp.	6	9				3	2	14	2	1	30		10	19	2	135	34	1
Mesotaxis asymmetrica																1		
Palmatolepis spp.																1	1	

Table 6

Distribution and frequency of the Frasnian, Famennian and Tournaisian platform conodonts in the Świerzno *4*, Chmielno *1* and Koczała *1* sections; *see* Text-fig. 3 for full names of the conodont zones; reworked conodonts are asterisked

CONODONT ZONES	HA₂–HB₁		CR 1–2	CR ?	RO₁	PO₂ – EX₁	EX₁		?		EX₂		EX₃?						EX₃–PR₁		SU?
[2] Świerzno *4* [30] Chmielno *1* [36] Koczała *1*	[36]										[2]		[30]								
depth [m] Conodonts	2716–2710	2710–2705	2337–2332	2292–2286	2250–2246	2177–2176	2172–2171	2171–2166	2166–2154	2137–2131	3200–3198	3198–3195	4512–4511	4504–4503	4457–4456	4420–4419	4416–4415	4402–4401	4140–4139	4010–4009	3953–3952
Icriodus praealternatus	1																				
Polygnathus decorosus		1																			
Polygnathus communis communis				1																	
Palmatolepis circularis			1																		
Palmatolepis quadrantinodosalobata			1																		
Palmatolepis tenuipunctata				2																	
Palmatolepis poolei					1																
Alternognathus sp. *B*				1																	
Pelekysgnathus inclinatus						1						1									
Mehlina strigosa								1						1	1		1				
Scaphignathus velifer velifer							*1														
Scaphignathus ziegleri							2														
Polygnathus bouckaerti							1														
Polygnathus semicostatus						10	2	15	1	1								1			
Polygnathus szulczewskii								2													
Clydagnathus ormistoni						2	4	1													
"Icriodus" raymondi												1									
Bispathodus aculeatus aculeatus											2					1					
"Pandorinellina cf. insita"													1								
Polygnathellus giganteus															1						
Bispathodus costatus morphotype 2																				2	
Pandorinellina plumula																			1		
Pseudopolygnathus dentilineatus																					1
Siphonodella sp.																					1

Table 7

Distribution and frequency of the Famennian and Tournaisian platform conodonts in the Wierzchowo *4*, Rzeczenica *1* and Bielica *1* sections; *see* Text-fig. 3 for full names of the conodont zones

CONODONT ZONES	EX_3–PR_1					SN				CB_1		EX_3–PR_1		SN – CB_1
	31	[38]										[39]		
[31] Wierzchowo *4* [38] Rzeczenica *1* [39] Bielica *1* depth [m] Conodonts	4975–4965	3303–2999	2950–2946	2937–2933	2925–2924	2922–2920	2920–2916	2916–2912	2912–2907	3517–3516	3587–3586	3710–3709	2899–2896	2901–2899
Bispathodus aculeatus aculeatus	2	2	1	1	1				1					
Bispathodus costatus morphotype 2	1	2										3	2	
Bispathodus stabilis morphotype 1					5			1	1					
Bispathodus ultimus morphotype 2		7			4									
Branmehla inornata		3												
Branmehla suprema					1									
Polygnathus communis communis		1				19	1	2	15	1				
Polygnathus delicatulus		1												
Polygnathus semicostatus	1													
Pseudopolygnathus dentilineatus									2					1
Pseudopolygnathus nodomarginatus									1		4			
Pseudopolygnathus primus									2		1			
Pseudopolygnathus radinus											1			
Pseudopolygnathus triangulus triangulus														1
Polygnathus distortus											1			
Polygnathus inornatus						1		1	4	1	13			1
Polygnathus longiposticus									1					
Polygnathus purus purus						10								
Polygnathus purus subplanus								1						
Polygnathus spicatus							1							
Polygnathus symmetricus									1		2			
Elictognathus bialatus						1			1					
Elictognathus laceratus						1					3			
Siphonodella duplicata						1			3					
Siphonodella obsoleta									1	1	4			
Siphonodella sandbergi						3								
Siphonodella sulcata									1					
Siphonodella quadruplicata									3		8			
Siphonodella crenulata										1	1			

Table 8

Distribution and frequency of the Famennian platform conodonts in the Brda *1*, Bielica *2* and Babilon *1* sections; *see* Text-fig. 3 for full names of the conodont zones

CONODONT ZONES	?			MR_2			MR_{2-3}			PO_1 – EX_1	EX_2 ?			EX_3–PR_1				
	[40]									[42]						[37]		
[37] Brda *1* [40] Bielica *2* [42] Babilon *1* depth [m] Conodonts	3968–3967	3865–3864	3853–3852	3807–3806	3795–3794	3770–3769	3767–3766	3764–3763	3760–3759	3286–3280	3214–3207	3193–3189	3126–3121	2956–2949	2641–2635	3201–3196	3192–3187	3022–3016
Polygnathus bouckaerti									1									
Polygnathus glaber bilobatus				1	1													
Polygnathus semicostatus	1	1	1															
Palmatolepis glabra distorta							1	1										
Palmatolepis glabra pectinata						1												
Palmatolepis glabra prima						1												
Palmatolepis marginifera marginifera							1											
Palmatolepis perlobata schindewolfi									1									
Bispathodus stabilis morphotype 1										1								
Clydagnathus ormistoni										1								
Bispathodus aculeatus aculeatus											1		3					
Bispathodus aculeatus anteposicornis											1							
Mehlina strigosa												1	1			1	1	
Polygnathus delicatulus											1					1		1
Bispathodus costatus morphotype 1															1	1		1
Pandorinellina plumula														4				
Polygnathus communis communis														1		2		

Table 9

Distribution and frequency of the Famennian platform conodonts in the Człuchów *IG-1* section; *see* Text-fig. 3 for full names of the conodont zones; reworked conodonts are asterisked

CONODONT ZONES	MR$_{1-2}$	MR$_{2-3}$			?		EX$_1$												
[41] Człuchów *IG-1* depth [m] Conodonts	3352–3351	3284–3283	3224–3223	3211–3210	3146–3145	3153–3152	3083–3082	3075–3074	2933–2932	2997–2996	2929–2928	2924–2923	2919–2918	2916–2915	2915–2914	2902–2901	2901–2900	2893–2892	2883–2882
Pelekysgnathus inclinatus				1															
Polygnathus glaber bilobatus				1						*1									
Polygnathus nodocostatus nodocostatus	1																		
Polygnathus pomeranicus			15																
Polygnathus semicostatus				4	4		2	1	6		5					5	3	1	
Polygnathus szulczewskii						1		1	7						5				
Palmatolepis glabra lepta	1		1																
Palmatolepis marginifera marginifera		1																	
Palmatolepis perlobata schindewolfi		1																	
"Icriodus" raymondi									7										
Bispathodus stabilis morphotype 1											1	2	2	1					
Branmehla sp.										1									
Mehlina strigosa												1			1				
"Pandorinellina cf. *insita"*										1					1				
Polygnathus communis communis									4										
Polygnathus experplexus							2	1							2	1			1
Polygnathus streeli								1					1						1
Polygnathus subirregularis							1												1
Alternognathus costatiformis									4										

Table 10

Distribution and frequency of the Famennian platform conodonts in the Krojanty *1* section; *see* Text-fig. 3 for full names of the conodont zones

CONODONT ZONES	?		PO$_2$–EX$_1$		?		EX$_3$				
[48] Krojanty *1* depth [m] Conodonts	3017–3013	3004–3002	2985–2984	2961–2957	2927–2925	2947–2945	2810–2806	2747–2743	2660–2655	2655–2650	2614–2609
Branmehla inornata				1							
Mehlina strigosa				1					1		1
Polygnathus bouckaerti			1								
Polygnathus perplexus	1		1								
Polygnathus pomeranicus	1		3								
Polygnathus semicostatus		4		2							
Clydagnathus ormistoni			1	1							
Pelekysgnathus inclinatus					2						
"Pandorinellina cf. *insita"*						1			1	1	
Bispathodus aculeatus aculeatus										1	1
Bispathodus stabilis morphotype 1							1		1	1	
Polygnathus delicatulus							1	1	1		
Polygnathellus giganteus									1		
Hemilistrona pulchra										1	

Table 11

Distribution and frequency of the Famennian platform conodonts in the Chojnice *2* section; *see* Text-fig. 3 for full names of the conodont zones

CONODONT ZONES	MR$_1$													MR$_{2-3}$			
[45] Chojnice *2* depth [m] Conodonts	3172–3167	3167–3160	3160–3154	3154–3148	3148–3142	3142–3136	3136–3129	3129–3123	3123–3117	3117–3111	3111–3105	3105–3099	3099–3093	3093–3086	3086–3082	3071–3065	3063–3058
"Ioriodus" chojnicensis									1	1	1	1	4				
Mehlina strigosa			1														
Polygnathus communis communis	1										1						
Polygnathus fallax													1	2			
Polygnathus limbatus									21			1					
Polygnathus pomeranicus						1	1	1	1				1	2			
Polygnathus semicostatus	4	1	5				1					1				1	1
Polygnathus szulczewskii	1																
Palmatolepis glabra pectinata		1					1						2				
Palmatolepis marginifera marginifera			1						1								
Palmatolepis minuta minuta	1													1			
Palmatolepis rhomboidea					1												
Palmatolepis quadrantinodosa quadrantinodosa	1	1	1														
Palmatolepis quadrantinodosa inflexa					1												
Palmatolepis quadrantinodosa inflexoidea					1								1				
Palmatolepis stoppeli				1	1												
Alternognathus pseudostrigosus							1						2			1	1

Table 12

Distribution and frequency of the Famennian platform conodonts in the Chojnice *4* and Choj *5* sections; *see* Text-fig. 3 for full names of the conodont zones

CONODONT ZONES	TI$_3$ – CR$_1$	CR$_{2-4}$	RO$_2$	MR$_1$	MR$_2$	MR$_{2-3}$	MR$_{1-3}$							MR$_3$	
	[49]						[50]								
[49] Chojnice 5 [50] Chojnice 4 depth [m] Conodonts	3460–3457	3240–3235	3112–3110	3007–3004	2908–2906	2897–2896	3076–3072	3072–3066	3066–3061	3061–3058	3058–3056	3047–3043	3043–3030	3022–3010	3010–3001
Ioriodus iowanensis iowanensis		1													
Palmatolepis minuta wolskae		1													
Palmatolepis tenuipunctata	1														
Palmatolepis triangularis	1														
Palmatolepis triangularis→Pal. quadrantinodosalobata	1														
"Ioriodus" chojnicensis			1												
Palmatolepis glabra pectinata			1		1										
Palmatolepis rhomboidea			1												
Pelekysgnathus inclinatus				2											
Polygnathus pomeranicus				4	7		1	1			1	1	1		5
Polygnathus semicostatus				1		1	2	2	2	1			1		1
Polygnathus szulczewskii				1											
Palmatolepis quadrantinodosa quadrantinodosa				3											
Polygnathus bouckaerti									1	1					
Polygnathus communis communis								1							
Polygnathus fallax								3	1						
Polygnathus glaber glaber						3	1								
Polygnathus glaber bilobatus					1										1
Palmatolepis marginifera marginifera						1	1								
Polygnathus granulosus														1	
Alternognathus regularis															1

Table 13

Distribution and frequency of the Frasnian platform conodonts in the Chojnice *3* section; *see* Text-fig. 3 for full names of the conodont zones

CONODONT ZONES	HA₂–RH₁			RH₁									
[47] Chojnice 3 depth [m] Conodonts	2889–2879	2855–2848	2848–2843	2798–2793	2786–2783	2743–2742	2734–2722	2702–2698	2680–2672	2558–2553	2553–2550	2540–2533	2533–2531
Icriodus praealternatus											1	1	1
Icriodus symmetricus					6								
Pelekysgnathus brevis										1			
Ancyrodella lobata					1								
Polygnathus aequalis		3			3		1			1			
Polygnathus alatus	1		1		14	2	1	1	1			2	
Polygnathus ?aspelundi												1	
Polygnathus brevilaminus				2	2	1							
Polygnathus decorosus	1		1	1	9							3	
Polygnathus evidens									1				
Polygnathus morgani								1					
Polygnathus pacificus					2				2		2		
Polygnathus robustus									1				
Polygnathus spp.	5			1					1				
Palmatolepis hassi			1										
Palmatolepis jamieae												1	
Palmatolepis simpla					1								

Table 14

Distribution and frequency of the Frasnian and Famennian platform conodonts in the Unisław *2* section; *see* Text-fig. 3 for full names of the conodont zones; reworked conodonts are asterisked

CONODONT ZONES	HA₂–RH₁			RH₁				RH₂			LI?	TI₁₋₂					TI₂	MR₂		MR₂–?TA	
[55] Unisław 2 depth [m] Conodonts	4974–4973	4727–4726	4718–4717	4716–4715	4697–4696	4693–4692	4689–4688	4672–4671	4670–4669	4664–4663	4648–4647	4645–4644	4644–4643	4640–4639	4639–4638	4637–4636	4636–4635	4531–4530	4519–4512	4497–4496	4475–4474
Icriodus subterminus	2			1																	
Icriodus symmetricus	2	3	6			3	4														
Polygnathus aequalis							14														
Polygnathus alatus	3	3																			
Polygnathus decorosus	3	2	5			31	6														
Polygnathus evidens	27	2	19				2														
Polygnathus pacificus							1	1													
Polygnathus robustus	6						2														
Polygnathus webbi									4	48	47										
Polygnathus spp.					3							14			2	12					
Ancyrodella curvata late morph.								1			7										
Ancyrodella gigas										5											
Ancyrodella nodosa	2						7		1	2											
Ancyrognathus triangularis									1	1	15										
Ancyroides leonis							2														
Palmatolepis barba						5	2														
Palmatolepis foliacea									1												
Palmatolepis hassi	1		1			36	5			20	1										
Palmatolepis jamieae									1												
Palmatolepis rhenana nasuta							17		12	3		*2									
Palmatolepis plana	16						2			1											
Palmatolepis proversa	3						9														
Palmatolepis punctata					1	23	9														
Palmatolepis simpla							1			1											
Palmatolepis subrecta								7			130	*3									
Palmatolepis linguiformis												*2									
Icriodus alternatus												4				4					
Icriodus alternatus alternatus									3	1	24	52	6			36					
Icriodus alternatus helmsi												1	4			10					
Icriodus iowaensis iowaensis																1					
Polygnathus brevilaminus																2					
Polygnathus praecursor													3		6	13					
Polygnathus procerus																5					
Palmatolepis praetriangularis												12	2	1	1	12					
Palmatolepis triangularis												24	2		1	11					
"*Icriodus*" *cornutus*																	1				
Polygnathus communis communis																					1
Polygnathus semicostatus																				2	
Palmatolepis glabra lepta																					2
Palmatolepis glabra prima																		1	1		

The uppermost Frasnian *linguiformis* Zone was tentatively noted in the Unisław-*2* section (MATYJA & NARKIEWICZ 1992b) on the basis of the last occurrence of *Polygnathus webbi*, *Palmatolepis hassi*, *Pal. subrecta*, *Ancyrognathus triangularis*, and *Ancyrodella curvata* and by the absence of *Palmatolepis triangularis*. Identification of the *linguiformis* Zone is not certain here because of the absence of the zonal indicator (*compare* Text-fig. 6 and Table 14; *see also* Pl. 23).

FAMENNIAN CONODONT ZONES

The unseparated Lower-Middle *triangularis* Zones were determined by the co-occurrence of *Palmatolepis triangularis* and *Pal. praetriangularis*, accompanied by *Icriodus alternatus alternatus*, *I. alternatus helmsi*, and *Polygnathus praecursor*. The Middle *triangularis* Zone has been recorded in the Unisław-*2* section only, where all the species mentioned have been found in addition to "*Icriodus*" *cornutus*. The appearance of "*Icriodus*" *cornutus* marks the beginning of this zone (Text-fig. 7 and Table 14; *see also* Pl. 24).

The Upper *triangularis* Zone has been recognized in two sections, Wudzyń-*1* and Gorzysław-*14*, where *Icriodus alternatus alternatus*, *Palmatolepis triangularis* and *Polygnathus praecursor* have been found in addition to *Palmatolepis minuta minuta*, *Pal. tenuipunctata*, and *Pal. triangularis-quadrantinodosalobata*, the appearance of which marks the beginning of this zone (*see* Text-fig. 7, Table 2 and Pl. 25).

It is difficult to separate the Lower from Middle *crepida* Zone. The presence of *Palmatolepis circularis* together with *Palmatolepis quadrantinodosalobata* does not allow one to decide whether the Lower or Middle *crepida* Zone occurs. A similar problem exists for the separation of the Upper and Uppermost *crepida* Zone. The subspecies *Palmatolepis perlobata schindewolfi* which first occured in the latest part of the Upper *crepida* Zone has been found in addition to *Icriodus iowanensis iowanensis*, *Polygnathus procerus*, *Pol. nodocostatus ovatus*, *Palmatolepis tenuipunctata* and *Pal. minuta wolskae* ranging into the Uppermost *crepida* Zone (*see* Text-fig. 7, Tables 1-3, 6, 12 and Pl. 26, Figs 7-8).

The Lower *rhomboidea* Zone has been recorded only in the Koczała-*1* section on the basis of a single occurrence of *Palmatolepis poolei*. This species appears to be restricted to the lowermost part of the Lower *rhomboidea* Zone (*compare* Text-fig. 7 and Table 6).

The Upper *rhomboidea* Zone was determined on the basis of co-occurrence of "*Icriodus*" *chojnicensis*, *Palmatolepis glabra pectinata* and *Pal. rhomboidea* and by the absence of *Pal. marginifera marginifera* (*compare* Text-fig. 7 and Table 12; *see also* Pl. 27, Figs 4, 7).

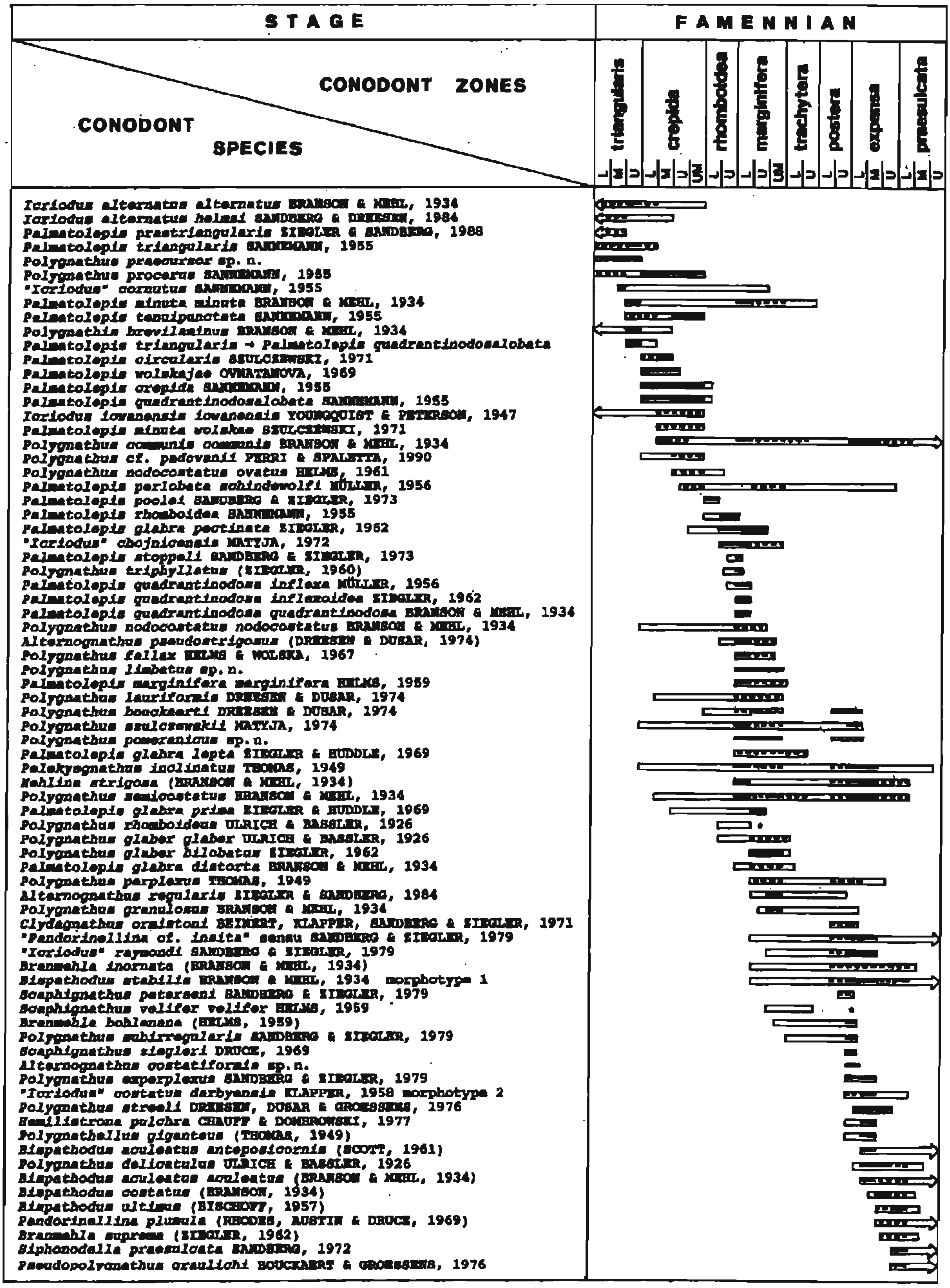

Fig. 7. Range chart of the Famennian conodonts in Western Pomerania

Solid bars indicate certain recognition of the zone, dashed bars indicate uncertain recognition of the zone in comparison with total ranges (*empty bars*); schemes *after* DREESEN & DUSAR (1974); CHAUFF & DOMBROWSKI (1977); KLAPPER & W. ZIEGLER (1979); SANDBERG & W. ZIEGLER (1979); W. ZIEGLER & SANDBERG (1984); SANDBERG & DREESEN (1984); DREESEN, SANDBERG & W. ZIEGLER (1986); W. ZIEGLER & SANDBERG (1990); reworked conodonts are asterisked

The Lower *marginifera* Zone is rather easy to distinguish throught the area on the basis of the co-occurrence of *Palmatolepis marginife mrginifera, Pal. glabra lepta, Mehlina strigosa, Polygnathus fallax, Pol. limbatus* and *Pol. pomeranicus* which mark the beginning of the zone and *Palmatolepis quadrantinodosa inflexa, Pal. quadrantinodosa inflexoidea, Pal. qudrantinodosa quadrantinodosa* and *Pal. stoppeli* extending to the top of the zone (Text-fig. 7; Tables 3, 11-12; Pl. 27, Figs 1-3, 5-6, 8-13; Pl. 28; Pl. 29, Figs 1-2, 5-7 and 10).

The Upper *marginifera* Zone is characterized by the range of *Palmatolepis marginifera marginifera* between the last occurrence of *Pal. quadrantinodosa quadrantinodosa* and the first occurrence of *Scaphignathus velifer* (*see* Text-fig. 7). The range of *Pal. marginifera marginifera* together with *Polygnathus glaber bilobatus* is here taken to identify this zone but sometimes it is difficult to separate the Upper from the Uppermost *marginifera* Zone (*see* Text-fig. 7; Tables 1, 3, 8-9, 11, 14; Pl. 30). The most common association consists of *Palmatolepis glabra pectinata, Pal. glabra prima,* and *Polygnathus pomeranicus* (*see* Tables 8, 12, 14).

The Uppermost *marginifera* Zone is recognized by appearance of *Alternognathus regularis* and *Polygnathus granulosus,* although the occurrence of *Polygnathus semicostatus, Pol. pomeranicus, Pol. glaber glaber* and *Pol. glaber bilobatus* were noted here. Some forms as "*Icriodus*" *chojnicensis, Polygnathus limbatus, Pol. glaber glaber, Pol. glaber bilobatus, Pol. fallax, Alternognathus pseudostrigosus,* and *Palmatolepis glabra distorta* range to the top of the zone (*compare* Text-fig. 7 and Table 12).

It was not possible to document the *trachytera* and *postera* Zones in the investigated area (*see* Text-fig. 7 and Tables 1-14). The inability to recognize these zones within the very shallow-water Krojanty and Kłanino formations may be due to unfavorable environmental conditions for the zones-indicative taxa (*see* ZIEGLER & SANDBERG 1984b). On the other hand, low net sedimentation possibly falling on the *trachytera* and *postera* Zones (*see* Text-figs 3*B* and 4) suggests as well a real nondeposition gap.

The Lower *expansa* Zone is documented by the presence of *Polygnathus experplexus, Pol. subirregularis,* and *Scaphignathus ziegleri* as well as by many other species, i.e. *Polygnathus bouckaerti, Pol. communis communis, Pol. perplexus, Pol. pomeranicus, Pol. semicostatus, Pol. szulczewskii, Pelekysgnathus inclinatus, Mehlina strigosa, Clydagnathus ormistoni,* "*Pandorinellina* cf. *insita*", "*Icriodus*" *raymondi, Scaphignathus peterseni, and* "*Icriodus*" *costatus darbyensis* (Text-fig. 7; Tables 1-2, 6, 8-10; Pls 31-34; Pl. 35, Figs 1, 3-4). However, among the conodonts typical of the Lower *expansa* Zone, there were found some species, characteristically occurring in older conodont zones, as *Polygnathus* cf. *glaber bilobatus* or *Scaphignathus velifer velifer* (*see* Text-fig. 7, Tables 6 and 9). The subspecies *Polygnathus glaber bilobatus* is noted from the Upper and Uppermost *marginifera* Zones, and the range of *Scaphignathus velifer velifer* is limited to the Uppermost *marginifera* and Lower *trachytera* Zones (*see* Text-fig. 7). Neither of them has so far been found in the Lower *expansa* Zone. In the light of the available data it is hardly to determine whether these forms have been redeposited from older Famennian sediments or they may perhaps indicate a stratigraphic condensation; the first hypothesis seems to be the most probable.

The Middle *expansa* Zone is characterized by the presence of *Polygnathus delicatulus, Pol. streeli, Bispathodus aculeatus aculeatus, Bi. aculetaus anteposicornis, Branmehla inornata, Hemilistrona pulchra,* and *Polygnathellus giganteus* (*see* Text-fig. 7; Tables 2-3, 6, 8, 10; Pl. 35, Figs 2, 5-9; Pl. 36, Figs 1-2, 4).

The Upper *expansa* and Lower (or lowermost Middle) *praesulcata* Zones were recognizable due to the presence of numerous species of the genus *Bispathodus* only and the occurrence of *Siphonodella praesulcata* as the last palmatolepids which are the basis for the Late Devonian standard zonation disappear in the Pomeranian basin at the end of *marginifera* Chron owing to ecological reasons. Moreover, it is not possible to separate the Upper *expansa* Zone from the Lower *praesulcata* Zone in the most of investigated sections because of the extremely rare occurrence of *Siphonodella praesulcata.* These two inseparable zones are characterized in Western Pomerania by the presence of *Bispathodus costatus, Bi. ultimus, Bi. aculeatus aculeatus, Branmehla suprema,* and *Pandorinellina plumula* (Text-fig. 7; Tables 2-3, 6-8; Pl. 36, Figs 3, 5-10).

The base of the Lower Carboniferous sequence is characterized by rare though relatively diverse conodonts. The presence of *Siphonodella obsoleta, S. quadruplicata, Elictognathus bialatus and E. laceratus,* as well as many other species of the genera *Polygnathus, Pseudopolygnathus,* and *Bispathodus* below the first occurrence of *Siphonodella crenulata* (*see* Tables 3 and 6-7) allow the fragments of the sequence to be attributed to the upper *sandbergi* Zone (*see* SANDBERG & *al.* 1978, VARKER & SEVASTOPULO 1985, WEBSTER & GROESSENS 1990).

Conodont zones younger than the Lower (or lowermost part of the Middle) *praesulcata* Zone but older than the upper part of Lower Carboniferous *sandbergi* Zone have not been found as yet in the studied area (*see* Tables 1-14). Thus, the stratigraphic gap comprises the uppermost Devonian (part of the Middle and Upper *praesulcata* Zones) and the lowermost Carboniferous (the *sulcata, duplicata* and part of the *sandbergi* Zones). The range of this stratigraphic gap has been determined also by the miospore analysis.

The miospore assemblage of the uppermost Devonian represents the local *Tumulispora rarituberculata* (RA) Zone (TURNAU 1978). According to TURNAU (1979), the upper part of this zone should be correlated at least with part of the European *lephidophyta-nitidus* (LN) Zone on the base of the occurrence of such species as *Verrucosisporites nitidus* and *Umbonatisporites abstrusus.* Recently, however, the comparison of the composition of RA assemblage with the LE and LN assemblages of Western Europe, as well as with their counterparts in central Poland and Byelorussia showed that the species *Vallatisporites vallatus, V. verrucosus, V. pusillites,* and *Hymenozonotriletes explanatus,* important components of the LE and LN faunas, are missing in the

Pomeranian RA Zone. Therefore, AVCHIMOVITCH & *al.* (1993) considers the local RA Zone to be older than the European LE Zone, which is correlated with the Lower or Middle *praesulcata* conodont Zone. The top of the RA Zone can be correlated with the lowermost part of the Middle *praesulcata* Zone at the earliest, as has been confirmed by ranges of conodots co-occurring with RA Zone spores (MATYJA & TURNAU 1989).

In all Western Pomeranian sections, deposits with the RA miospore Zone assemblages are overlain by those of the *Convolutispora major* (MA) local Zone. On the basis of co-existing conodonts the lower limit of the MA Zone can be correlated with the upper *sandbergi* conodont Zone (MATYJA & TURNAU 1989). The presence of the species *Grandispora upensis* in the lowermost part of the zone suggests the possibility of correlation of the MA Zone with the *upensis* Zone of Byelorussia which is, in turn, correlated with the *sandbergi* conodont Zone (AVCHIMOVITCH & *al.* 1993). CLAYTON & TURNAU (1990) placed the base of the MA Zone at the top of the West European *verrucosus-incohatus* (VI) Zone.

It seems that the counterparts of the West European miospore zones *lepidophyta-explanatus* (LE), *lepidophyta-nitidus* (LN), and most of the *verrucosus-incohatus* (VI) Zone are missing in the Western Pomerania area.

It is noteworthy that both conodont and spore analysis suggest the existence of a stratigraphic gap of almost the same range.

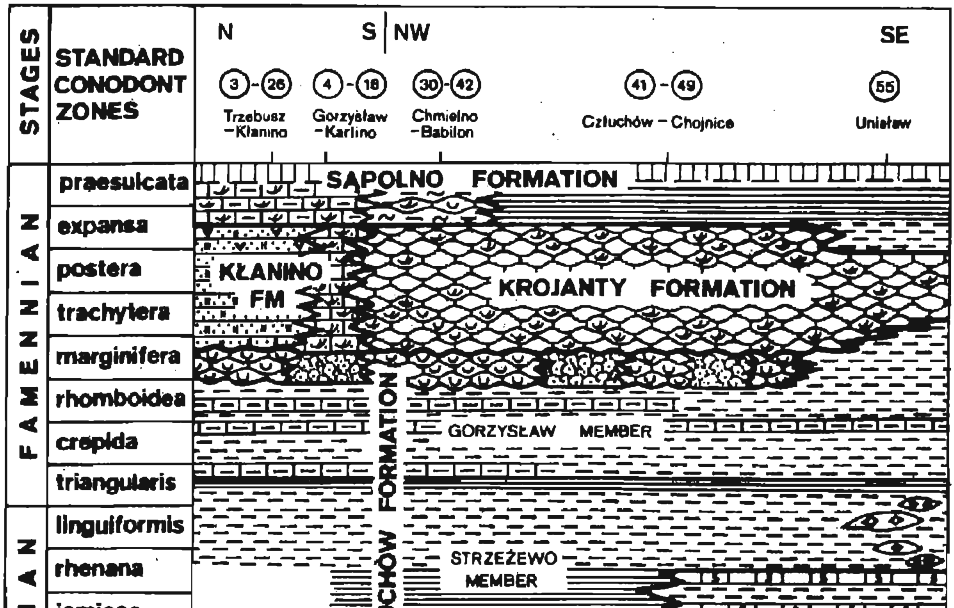

Fig. 8. Chronostratigraphic section through Western Pomerania; conodont zonation *after* W. ZIEGLER & SANDBERG (1990)

Vertical scale refers to time, not to thickness of deposits; horizontal distance is about 256 km (*see* Text-fig. 3*A* for lithofacies key)

UPPER DEVONIAN STAGE BOUNDARIES

The boundaries between Upper Devonian stages have long been a focus for attention by the IUGS International Commission of Stratigraphy. The Subcommission on Devonian Stratigraphy has formally agreed upon the nomenclature for the two standard Upper Devonian stages: the boundary between the Middle and Upper Devonian series coincident with the lower boundary of the Frasnian Stage, and the boundary between the Upper Devonian and Tournaisian series coincident with the lower boundary of the Hastarian Stage.

The most modern method of dating with adequate precision requires knowledge of event stratigraphy and biotic extinctions. Increased knowledge of event stratigraphy and extinction throughout the Late Devonian and detailed evidence of its events invalidate the selection of some limits as boundary levels. For example, new data on the Kellwasser Event invalidated the selection of the lower limit of the Middle *triangularis* Zone and compelled acceptance of the lower limit of the Lower *triangularis* Zone as the Frasnian/Famennian boundary level (*see* SANDBERG & *al.* 1988a). The fact that this level followed immediately, without hiatus, the late Frasnian global mass extinction was the argument for the choice.

GIVETIAN/FRASNIAN BOUNDARY

The boundary between the Middle and Upper Devonian series is coincident with the lower boundary of the Frasnian Stage. The original decision of the IUGS Subcomission on Devonian Stratigraphy intended to place the series and stages boundary at the base of the Lower *asymmetricus* conodont Zone as defined by W. ZIEGLER (1971). According to W. ZIEGLER (1971) this zone was defined by the joint occurrence of *Polygnathus asymmetricus* and *Ancyrodella rotundiloba* prior to the first appearance of *Palmatolepis punctata* (*see* W. ZIEGLER 1985, W. ZIEGLER & KLAPPER 1985, BULTYNCK 1986, COWIE & *al.* 1989).

Unfortunately, in 1987 the Subcomission fixed the global stratotype section and point for the Middle/Upper Devonian boundary not at the base of the Lower *asymmetricus*, as had been previously agreed, but within the preceding Lowermost *asymmetricus* Zone. This decision was influenced by the different taxonomic concept of the key species *Ancyrodella rotundiloba* of KLAPPER (1985). As a result of discussions between SANDBERG & *al.* (1988a) and KLAPPER (1988), three new zones based on pelagic conodont species have been proposed by SANDBERG & *al.* (1989) instead of the former *asymmetricus* Zone. These, together with the existence of *Ancyrodella pristina* (the early form in the *Ancyrodella* lineage) from the stratotype section have been revealed as offering a mean for global correlation of the Middle/Upper Devonian boundary. SANDBERG & *al.* (1989) suggested that the first appearance of *A. pristina* marked the start of the Late Devonian Epoch. The newly proposed Lower *falsiovalis* (the former Lowermost *asymmetricus*) Zone now includes the boundary between the Givetian and Frasnian stages (SANDBERG & *al.* 1989, ZIEGLER & SANDBERG 1990). Even with these data, SANDBERG & *al.* (1989) were unable to provide a globally correlatable Standard Zonal boundary that coincided with the unfortunate position of the global stratotype section and point selected by the IUGS Subcomission.

Difficulties are met in the delineation of the Givetian/Frasnian boundary in the Western Pomerania area. It probably runs within the siliciclastic facies of the Wyszebórz and Chojnice formations which is disadvantageous for detailed correlation. Though conodonts occur in the Eifelian and Givetian they do not become the pre-eminent stratigraphic tool, below the Upper Devonian. The *falsiovalis* Zone which includes the Givetian/Frasnian boundary has not been proven here. Species of the pelagic genus *Mesotaxis* and neritic genus *Ancyrodella*, important for the Lower Frasnian biostratigraphy, are absent in siliciclastic facies for ecological reasons. The first common Devonian conodont fauna in Western Pomerania is that of the *punctata* Zone, recorded in the basal parts of the younger lithostratigraphic units, *i.e.* the Strzeżewo Member of the Człuchów Formation, and the Koczała Formation.

FRASNIAN/FAMENNIAN BOUNDARY

The Frasnian/Famennian boundary was tentatively placed at the base of the Middle *triangularis* Zone (ZIEGLER & KLAPPER 1985). In 1987, during the 2nd Devonian Symposium in Calgary the boundary was moved down to the base of the Lower *triangularis* Zone and was defined by the first occurrence of *Palmatolepis triangularis*.

The much-discussed Frasnian/Famennian biotic crisis during which mass extinction in many invertebrate fossil groups occurred (McLAREN 1982) seems to have been restricted to the Frasnian latest *linguiformis* Chron. Therefore, the lower limit of the Famennian Lower *triangularis* Zone is for paleontologic reasons an excellent level for the Frasnian/Famennian boundary. Moreover, physical breaks or condensed intervals are observed in many areas of neritic and pelagic facies during this time interval.

In the Western Pomeranian sections that have been examined, the Frasnian/Famennian boundary is accentuated by a clear change in conodont faunas near the boundary between the *linguiformis* and *triangularis* Zones. Some characteristic features of the facies sequence, especially a reduction in the rate of carbonate sedimentation, the presence of detrital intercalations as evidence of shallowing events, and/or decrease in the carbonate/clay ratio in the sediments, have also been observed close to that boundary (MATYJA & NARKIEWICZ 1992a, b).

DEVONIAN/CARBONIFEROUS BOUNDARY

The IUGS Working Group on the Devonian/Carboniferous boundary recommended in 1979 a new operational definition of the boundary. Accordingly, the first appearance of the conodont species *Siphonodella sulcata* within the evolutionary lineage from *S. praesulcata* to *S. sulcata* marks the Devonian/Carboniferous boundary. The Working Group also recommended adjustments to the lower limits of the Dinantian, Tournaisian, Mississippian, Kinderhookian, and other chronostratigraphic units of similar rank, in order to make them correspond exactly with the boundary proposed (*see* PAPROTH & STREEL 1985). Unfortunately, all efforts to find a section, which would fulfil the demands of the Working Group, especially the condition that specimens of *Siphonodella praesulcata* should be followed in a given section by *S. praesulcata-sulcata* transitional forms, have not brought, as yet, the satisfying results.

There are stratigraphic gaps in the majority of the sections investigated, at least in terms of the occurrence of the aforementioned conodonts. ZIEGLER & SANDBERG (1984a) argued that a short eustatic fall in sea level just before the end of the Devonian resulted in mass extinction of Devonian fossils, including many conodonts, in change from pelagic siphonodellid biofacies to more nearshore protognathodid biofacies, as well as in the abrupt lithologic changes at the Devonian/Carboniferous contact which were sometimes accompanied by the absence of some zones. Of the lithologic disturbances observed in the majority of sections the most characteristic are the changes from limestones to mudstones or the presence of regressive or turbiditic sandstones, hardgrounds and unconformities. Therefore, even in the best sections, the boundary itself could be determined only approximately (*see* ZIEGLER & *al.* 1988).

The Global Stratotype Section and Point for the Devonian/Carboniferous boundary has now been defined at La Serre, southeast MontagneNoire, France (*see* PAPROTH & *al.* 1991). La Serre section is far from being an ideal stratotype but it was the only section known at the time that showed the "evolutionary lineage of *Siphonodella praesulcata* to *Siphonodella sulcata*" (*see* FLAJS & FEIST 1988). The inconveniences of La Serre section, such as the lack of some important stratigraphic guides (for example cephalopods, spores, and ash layers for radiometric dating) and the existence of reworking sediments induced to support La Serre section by the auxiliary stratotype sections of Hasselbachtal in the Rhine Slate Mountains and Nanbiancun in China (*see* BECKER & PAPROTH 1993; BECKER & *al.* 1993).

In Western Pomerania the top of the Upper Devonian sequence yields abundant and diverse conodont fauna indicative of the Upper *expansa* and Lower (?or lowermost part of Middle) *praesulcata* Zones. The next recognizable conodont zone is the upper part of Lower Carboniferous *sandbergi* Zone (*see* Table 7). There are only several dozen centimetres of shale deposits rich in pyrite and organic matter, and devoid of fossils between the documented Devonian Upper *expansa* and/or Lower *praesulcata* Zones and the Carboniferous upper *sandbergi* Zone in the Rzeczenica-*1* and Gorzysław-*9* sections (*see* MATYJA 1993). Thus, the recognized stratigraphic gap comprises the uppermost Devonian (part of the Middle and Upper *praesulcata* Zones) and the lowermost Carboniferous (the *sulcata*, *duplicata*, and the lower part of the *sandbergi* Zone).

CONODONT BIOFACIES

The importance of conodonts has largely stemmed from their biostratigraphic potential. Similar conodont sequences were described from many parts of the world, and they seemed to represent a variety of marine environments. These very general observations lead to the conclusion that many conodonts were quite ubiquitous, thus an excellent tool for biostratigraphy but perhaps of little help in ecology. As more data on conodont distribution had became available through biostratigraphic studies, it was apparent that the lateral variations in conodonts occurrences are controlled by some ecological factors. Two contrasting models explaining the distribution of conodonts within sedimentary environments have been proposed. The *depth stratification model* that suggested nektic (pelagic) habits for conodont-bearing animals was outlined by SEDDON & SWEET (1971). Soonafter, DRUCE (1973) recognized that densities of conodonts might have decreased offshore in each of several depth-stratified populations. The *lateral-segregation model* of BARNES & FÅHRAEUS (1975) suggested that most of conodont-bearing animals were nektobenthic with a minority of truly pelagic forms. Although these two hypothesis seem to be very different, neither has been generally accepted (*see* SWEET 1988, POHLER & BARNES 1990). It is thought that any explaining of the distribution of conodonts requires a combination of features of both the depth-stratification and lateral-segregation models. On the other hand, it is rarely possible to identify what a physical or chemical factor controlled the distribution observed.

Fortunately, the distribution of the Upper Devonian conodonts is generally defined by a number of distinctive biofacies, which have been identified, characterized and named by SANDBERG and his co-authors (*see* SANDBERG 1976, SANDBERG & ZIEGLER 1979, SANDBERG & DREESEN 1984, ZIEGLER & SANDBERG 1984b, SANDBERG & *al.* 1988b, 1989, 1992). Precisely, SANDBERG (1976) defined *a conodont biofacies* as a conodont community, which is characterized by a dominance of one or two platform genera. For all biofacies, the nominate platform genera constituted at least 65% of total platform conodont population. Later, SANDBERG & *al.* (1988) adopted a higher value, at least 70%.

It would be misleading to suggest that there is full agreement on all matters respecting the paleoecology of the Upper Devonian conodonts (*see* BEŁKA & WENDT 1992, MATYJA & NARKIEWICZ 1992b). These differences are, however, not so great and deal with the ecology of particular species rather than genera.

In most studies the relation between the conodont distribution and sedimentary environments was based on generic level. From detailed studies it is clear, however, that different species of one genus occupied different ecologic niches. Such specific adaptation is particularly observed (*see* SANDBERG 1976, SANDBERG & ZIEGLER 1979, MATYJA 1987, SANDBERG & *al.* 1989, DAY 1990) within the genera *Polygnathus* and *Icriodus*. It is necessary, therefore, to emphasize the most common species within the particular biofacies.

UPPER DEVONIAN BIOFACIES IN WESTERN POMERANIA

Several sedimentary environments and conodont biofacies are recognized in the studied Late Devonian sequence of Western Pomerania (*see* Text-figs 9-10 and 11-20). These support an idea that some environments are well characterized by definite conodont associations. The present study is expanded and considerable modified version of previously published results on the conodont biofacies in the Famennian of Western Pomerania (*see* MATYJA 1987).

The distribution of conodont taxa have been examined at the specific level and compiled at the generic level to compare with the conodont biofacies models proposed for the Late Devonian by SANDBERG (1976), SANDBERG & DREESEN (1984), and SANDBERG & *al.* (1988b, 1989, 1992).

The conodont frequencies are not high in particular samples, due to several reasons mentioned earlier, and they range from over hundred specimens to only a few specimens per 1 kg of rock sample (*see* Tables 1-14). The frequencies have been counted in comparative samples of the same age, the same lithofacies and within the similar sedimentary environment, to give the name of biofacies.

During the *punctata* Chron an extensive carbonate platform developed in the eastern part of the studied area (*see* Text-fig. 12), covered mainly by stromatoporoid-coral limestones. The limestones contain conodonts typical of the polygnathid biofacies as over 80% of specimens are represented (*see* Text-fig. 10) by *Polygnathus alatus* and *Polygnathus webbi*. The polygnathid biofacies also contain specimens of the species *Icriodus subterminus* (6%) and *Ancyrodella gigas* as well as *Anc. rotundiloba* (9%). Pelagic forms, such as *Mesotaxis asymmetrica* or *Palmatolepis* sp., are subordinately present and constitute an inferior component (only 1%).

No data exist that would make a recognition of biofacies pattern possible in open shelf environment during the *punctata* Chron (*see* Text-figs 9 and 12).

A very similar lithofacies pattern with a carbonate platform deposits in the east, and offshore sediments in the north and southwest (*see* Text-fig. 13) persisted up to the early Early *rhenana* Chron. A subtle change in conodont community is observed, however, both in the carbonate platform and open shelf environments. In the distal part of the carbonate platform sediments yield conodonts of the polygnathid-palmatolepid biofacies. The assemblage is mainly composed of *Polygnathus evidens* which together with other polygnathids

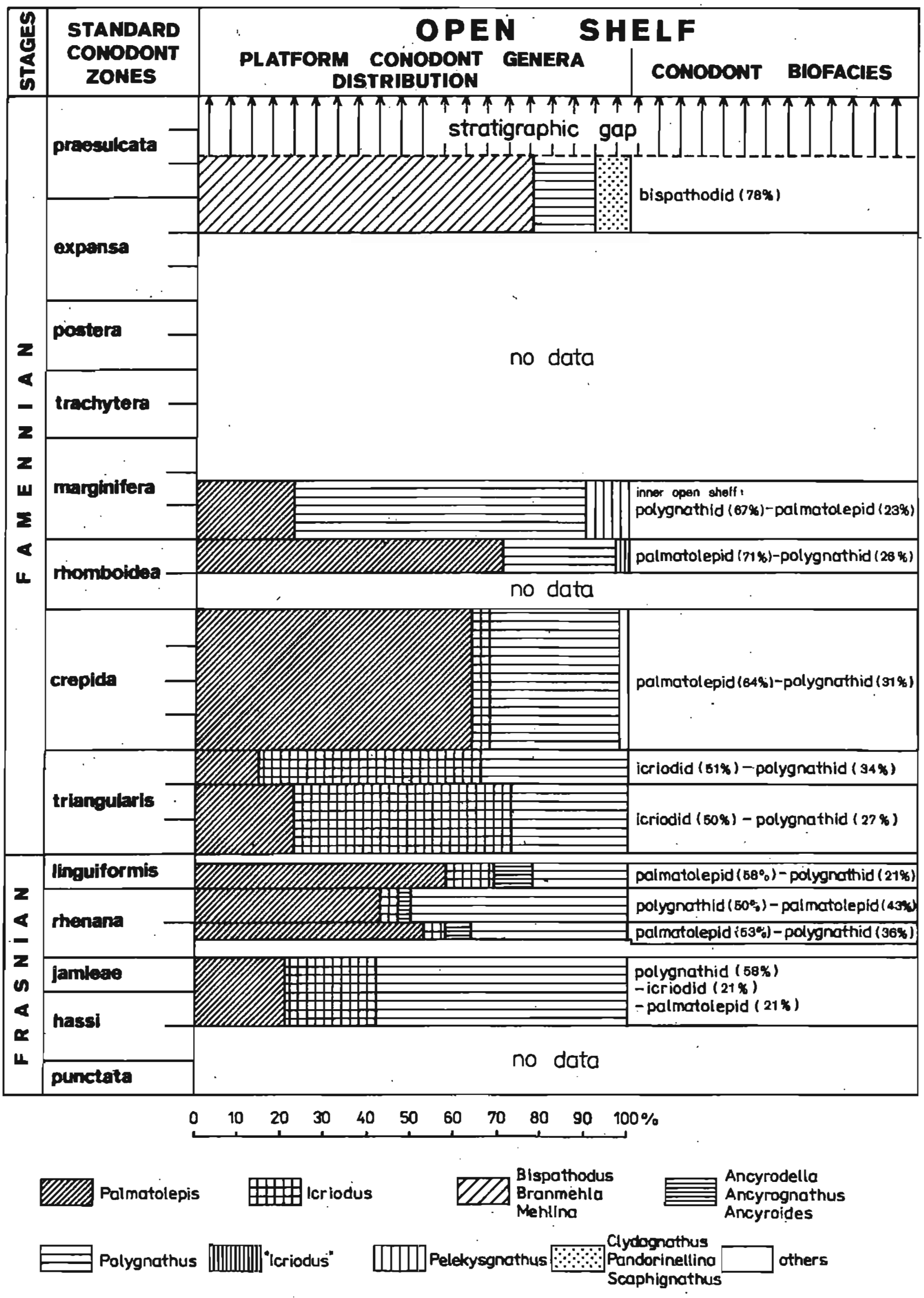

Fig. 9. Upper Devonian conodont biofacies and percentage distribution of the platform conodont genera in open-shelf environment (Western Pomerania)

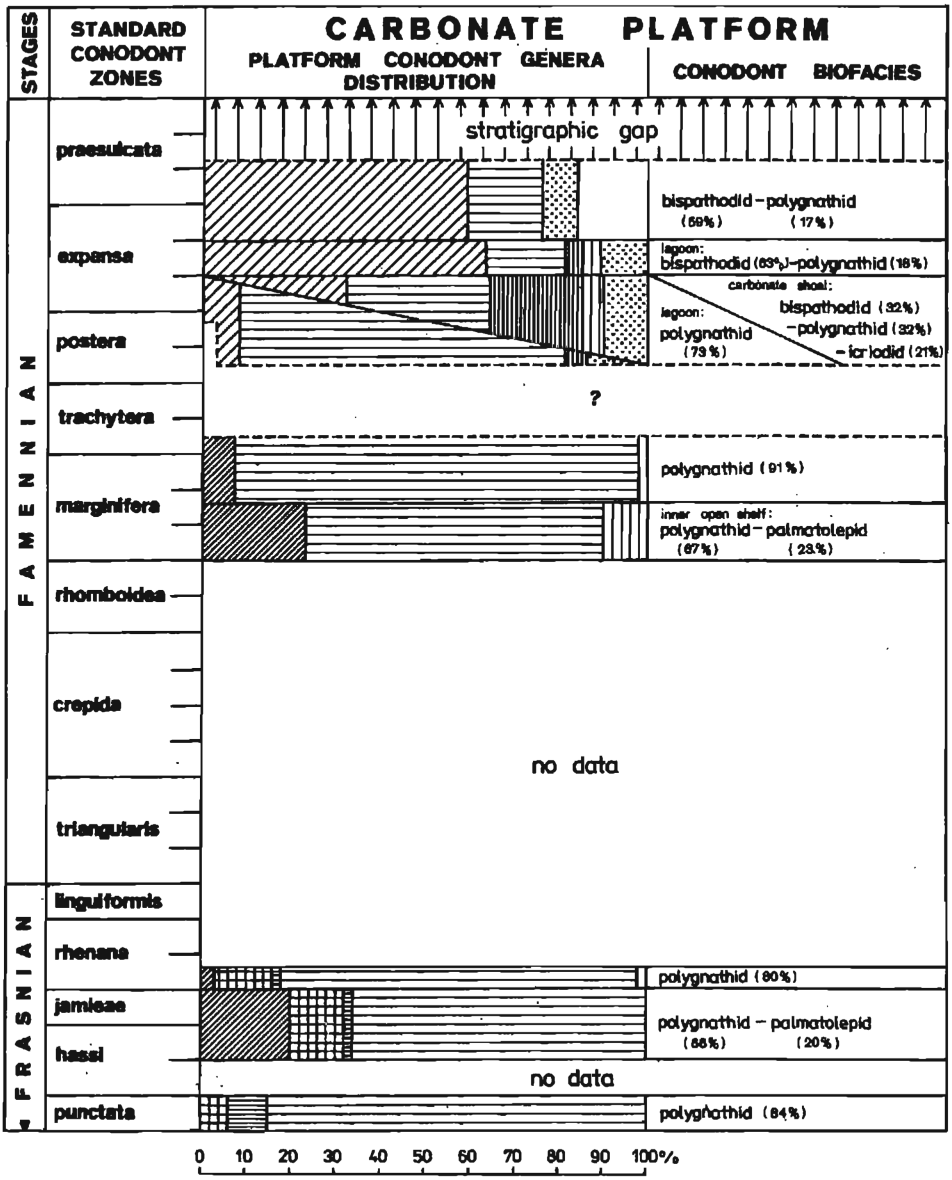

Fig. 10. Upper Devonian conodont biofacies and percentage distribution of the platform conodont genera in carbonate platform environments (Western Pomerania); *see* Text-fig. 9 for key to the conodont genera

(*Pol. alatus, Pol. decorosus, Pol. robustus*) constitute about 65% of platform conodont population. The biofacies (*see* Text-fig. 10) yields also about 20% of palmatolepids (*Palmatolepis plana, Pal. hassi,* and *Pal. proversa)* as well as about 12% of *Icriodus symmetricus* and *Icr. subterminus.* An open sea environment, close to the carbonate platform, was occupied by the mixed polygnathid-palmatolepid-icriodid biofacies, in which *Polygnathus webbi, Pol. decorosus* and *Pol. pacificus* constitute about 58% of the total platform elements, *Palmatolepis plana* about 21%, and *Icriodus symmetricus* about 21 %. Although most of the species of the genus *Icriodus* were inhabiting rather shallow-water environments, as suggested by SANDBERG & DREESEN (1984), *Icriodus symmetricus* preferred moderately deep water habitats (*see* SANDBERG & *al.* 1992). Thus, their presence together with true pelagic palmatolepids is not an exception.

At the beginning of the Early *rhenana* Chron an important change of conodont biofacies is noted. This bioevent is observable in a section situated in the distal part of the carbonate platform (*see* Text-figs 10 and 13). Here, the biofacies changes from the deeper polygnathid-palmatolepid to shallower polygnathid. The polygnathid fauna is dominated by four smooth species that constitute over 80% of its population; these are *Polygnathus aequalis, Pol. alatus, Pol. brevilaminus* and *Pol. pacificus.* The rest is composed of infrequent specimens of *Pol. aspelundi, Pol. decorosus, Pol. evidens, Pol. morgani,* and *Pol. robustus.* The polygnathid biofacies contains also 13% of *Icriodus praealternatus,* about 2% of *Pelekysgnathus brevis,* 2% of *Ancyrodella lobata,* and 3% of palmatolepids represented here by *Palmatolepis jamieae* and *Pal. simpla.*

The very distinct lithofacies change is recorded in the whole area at the end of the Early *rhenana* Chron. The carbonate platform was drowned and covered by deeper open-shelf shales and marls. This sedimentary regime persisted over the whole area up to the Famennian Middle *triangularis* Chron (*see* Text-fig. 14). The distinct biofacies change at the end of the Early *rhenana* Chron (*see* Text-fig. 9) is revealed when the shallow-water polygnathid biofacies, characteristic of the earliest Early *rhenana* Chron changes to the palmatolepid-polygnathid one. The polygnathids, dominated here by *Polygnathus decorosus* and *Pol. aequalis,* conversely decreased to only 36% and representatives of the pelagic genus *Palmatolepis* (mainly *Palmatolepis hassi* and *Pal. rhenana nasuta*) increased to 53%. The biofacies also contains *Icriodus symmetricus* and *I. subterminus* (8%), *Ancyrodella curvata* and *Anc. nodosa* (5%), as well as *Ancyroides leonis* (1%).

A conodont fauna of similar composition is noted from the Late *rhenana* Chron where the polygnathid-palmatolepid biofacies occurs locally. This biofacies is dominated by *Polygnathus webbi* attaining about 50% of platform conodont population, as well as by the different species of the genus *Palmatolepis,* with clear dominance of *Palmatolepis hassi* and *Pal. rhenana nasuta.* Other species, such as *Ancyrodella curvata, Anc. nodosa* (2%), *Ancyrognathus* *triangularis* (1%) and *Icriodus alternatus alternatus* (4%), are present but constitute an inferior component.

There is no marked facies turnover at the Frasnian/Famennian boundary. The critical interval near the *linguiformis*/*triangularis* zonal boundary displays, however, some lithological features that may be related to the Upper Kellwasser Event (*see* MATYJA & NARKIEWICZ 1992b). The conodonts of the early *linguiformis* Chron belong to the palmatolepid-polygnathid biofacies (*see* Text-fig. 9) which is composed of 58% of *Palmatolepis subrecta*, 21% of *Polygnathus webbi*, and 11% of *Icriodus alternatus alternatus*. This biofacies contains also *Ancyrodella curvata* (3%) and *Ancyrognathus triangularis* (6%). During the Early-Middle *triangularis* Chron the biofacies shift from the deeper palmatolepid-polygnathid to the shallower icriodid-polygnathid with a considerable admixture of the palmatolepid fauna is noted (*see* Text-fig. 9). The conodont fauna was then dominated by *Icriodus alternatus alternatus* and *I. alternatus helmsi* (nearly 49% of total platform population), *Polygnathus praecursor*, *Pol. procerus* and *Pol. brevilaminus* (27%), as well as *Palmatolepis praetriangularis* together with *Pal. triangularis* (23%). The genera *Ancyrodella* and *Ancyrognathus* are absent here, to confirm the view of SANDBERG & *al.* (1988b) that this group was decimated in the latest *linguiformis* Chron. This biofacies also contains (*see* Table 14) an admixture of older elements, representative of the *linguiformis* Zone, i.e. single specimens of *Palmatolepis subrecta*, *Pal. rhenana nasuta*, and *Pal. linguiformis*.

The lower Famennian deposits, from the Upper *triangularis* up to the *rhomboidea* Zone, still represent a deeper shelf (*see* Text-figs 15-16) although a much better oxygenated environment. Subtle changes of conodont biofacies are observed in the Late *triangularis* Chron. Although the icriodid-polygnathid biofacies is still present (*see* Text-fig. 9), a further decrease in the abundance of the genus *Palmatolepis* (from 23% in the Early-Middle *triangularis* Chron to about 15% in the Late *triangularis* Chron) is observed, whereas *Polygnathus* (*Pol. brevilaminus* and *Pol. praecursor*) becomes more important (27% in the Early-Middle *triangularis* Chron and 34% in the Late *triangularis* Chron). The species *Icriodus alternatus* maintains its position in the assemblage (49% in the Early-Middle *triangularis* Chron and 51% in the Late *triangularis* Chron).

Regularly alternating nodular marls and limestones, covering the whole investigated area from the Early up to the Latest *crepida* Chron (*see* Text-figs 15-16), contain conodonts which belong to the deep palmatolepid-polygnathid biofacies. Palmatolepids comprise here 64% of all the platform elements and include many different species, i.e. *Palmatolepis circularis*, *Pal. crepida*, *Pal. quadrantinodosa*, *Pal. tenuipunctata*, *Pal. wolskajae*. Polygnathids are represented by *Polygnathus communis communis*, *Pol.* cf. *padovanii*, *Pol. procerus*, and *Pol. nodocostatus ovatus* which together compose 31% of total platform conodonts. Other species constitute a minor component and are represented by *Icriodus iowanensis iowanensis* (2%) and *Alternognathus* sp. (3%). A similar biofacies is observed in the Late *rhomboidea* Chron (*see* Text-fig. 9), when *Palmatolepis klapperi, Pal. glabra pectinata, Pal. glabra acuta, Pal. glabra prima*, and *Pal. rhomboidea* constitute about 72% of the total platform elements. The deep-water *Polygnathus nodocostatus* group, represented here by *Polygnathus triphyllatus*, comprises 4%. Thus, 76% of the platform elements are of pelagic or offshore origin, whereas representatives of the nearshore, presumably nektobenthic *Polygnathus semicostatus* group (i.e. *Pol. pomeranicus, Pol. semicostatus*, and *Pol. szulczewskii*) constitute about 24%.

A very distinct and important change in the sedimentary environment from the deeper to the shallower inner shelf took place in the earliest *marginifera* Chron. The sedimentation of shallow-water, nodular bioclastic limestones, as well as bioclastic grainstones is stated in many spots of the investigated area. There were some places within the shallow shelf, however, where the carbonate buildups had grown on tectonically controlled intrabasinal highs (*see* Text-fig. 17). The nodular bioclastic limestones contain a conodont fauna representative of the polygnathid-palmatolepid biofacies. Thus, during the latest *rhomboidea* or earliest *marginifera* Chron the biofacies shift from the deeper palmatolepid-polygnathid to the shallower polygnathid-palmatolepid is observed. The conodont community was then dominated by shallow-water forms of the genus *Polygnathus* (i.e. *Polygnathus pomeranicus, Pol. semicostatus, Pol. szulczewskii, Pol. glaber, Pol. communis communis)* which conversely increased from 26% in the Late *rhomboidea* Chron to about 67% in the Early *marginifera* Chron. Different species of the pelagic genus *Palmatolepis* (*Pal. marginifera marginifera, Pal. quadrantinodosa quadrantinodosa*, and *Palmatolepis glabra*) conversely decreased from 71% in the Late *rhomboidea* to only 23% in the Early *marginifera* Chron (*see* Text-fig. 9). This biofacies contains also very shallow-water *Pelekysgnathus inclinatus* which comprises about 10% of total platform elements. Sparse conodonts, representing mainly the *Polygnathus semicostatus* group, as well as *Palmatolepis marginifera marginifera* and *Palmatolepis quadrantinodosa quadrantinodosa* have been found within the carbonate buildups lithofacies.

An important regressive event, reflected by overall progradation of nearshore environments to the south and southwest, abruptly affected the Pomeranian epicratonic sea with the beginning of the Late *marginifera* Chron. This very shallow, slightly restricted subtidal environment, probably connected with a low-angled foreslope of the carbonate platform, is characterized by the presence of the polygnathid biofacies (*see* Text-figs 10 and 18) as over 91% of specimens are represented here by shallow-water *Polygnathus pomeranicus* and *Pol. semicostatus*, as well as by probably ubiquitous *Pol. communis communis, Pol. glaber glaber, Pol. glaber bilobatus*, and *Pol. fallax*. The biofacies contains also sparse palmatolepids (i.e. *Palmatolepis marginifera marginifera, Pal. glabra lepta, Pal. glabra prima, Pal. perlobata schindewolfi*) and *Pelekysgnathus inclinatus*.

It is noticable that the last specimens of the offshore (or pelagic) genus *Palmatolepis* definitively retreated from the Pomeranian sea at the end of the *marginifera* Chron owing to ecological reasons.

No data exist that would make a recognition of the biofacies pattern possible within very shallow and probably coastal environments during the *trachytera* and *postera* Chrons. It is probable that during this period a real nondeposition gap took place.

At the beginning of the Early *expansa* up to the Middle *expansa* Chron almost the whole area was covered by south- and westwardly prograding extensive shallow-water and coastal environments (*see* Text-fig. 19). Conodont biofacies are recognizable only in two environments. The high-energy, carbonate-sand shoal environment, developed probably at the platform margin, is characterized by the mixed bispathodid-polygnathid-"icriodid" biofacies during the Early-Middle *expansa* Chrons (*see* Text-fig. 10). The biofacies includes different species of the ubiquitous genera *Bispathodus*, *Mehlina* and *Branmehla* (32%) and 68% of shallow-water and nearshore forms. These include *Polygnathus semicostatus* (32%), "*Icriodus*" *raymondi* and "*I.*" *costatus darbyensis* (21%), *Pelekysgnathus inclinatus* (5%), as well as "*Pandorinellina* cf. *insita*" (5%) and *Scaphignathus peterseni*. The last two species were very characteristic of nearshore, restricted and peritidal environments and occupied highly specialized niches, which were dominated by a single genus (*i.e.* pandorinellinid and scaphignathid biofacies respectively) as suggested by SANDBERG & ZIEGLER (1979). Shallow marine transport processes are invoked to have occasionally washed the conodonts out of these environments and mixed them with conodonts of the carbonate-sand shoal environment. A shallow, restricted lagoon environment, connected with the carbonate platform interior (*see* Text-fig. 19), contains a conodont fauna representative of the polygnathid biofacies in the Early *expansa* Chron (*see* Text-fig. 10). The biofacies is composed of shallow-water *Polygnathus pomeranicus*, *Pol. semicostatus*, *Pol. szulczewskii*, as well as of some representatives of the rather deeper-water *Polygnathus nodocostatus* group (i.e. *Polygnathus perplexus*, *Pol. subirregularis* and *Pol. bouckaerti*), which together comprise about 73% of all platform elements. Ubiquitous forms, such as *Mehlina strigosa* and *Bispathodus stabilis* comprise 8%. The shallow-water species "*Icriodus*" *raymondi* constitutes 5% and *Clydagnathus ormistoni* together with *Scaphignathus ziegleri*, both known from the restricted peritidal environments, about 11% (*see* Text-fig. 10). Within the lagoon environment the change of biofacies from polygnathid to bispathodid-polygnathid is observed in the Middle *expansa* Chron. The conodont community was then dominated by ubiquitous species of the genera *Bispathodus*, *Mehlina* and *Branmehla* which constitute about 63% of total platform elements, although still present are very shallow-water forms like "*Icriodus*" *raymondi*, *Pelekysgnathus inclinatus*, "*Pandorinellina* cf. *insita*" and *Polygnathus semicostatus* which constitute over 36% of total platform elements.

At the end of the Famennian, beginning with the Late *expansa* Chron, an open shelf environment became prevalent almost the whole area (*see* Text-fig. 20). Black marls and marly limestones contain conodonts indicative of the bispathodid-polygnathid biofacies which is composed mainly of ubiquitous forms, such as species of the genera *Bispathodus, Mehlina, Branmehla* (76%), and as *Polygnathus communis communis*. The polygnathids are represented here by *Polygnathus delicatulus* and the just mentioned *Pol. communis communis* which constitute together about 14%. Other conodont species occur as minor components (*see* Text-fig. 10). In the same time, the carbonate platform still existed in the northern part of the investigated area (*see* Text-fig. 20). Here, in the carbonate platform foreslope environment, the conodont biofacies is dominated by species of the genus *Bispathodus* (i.e. *Bi. costatus, Bi. stabilis*, and *Bi. ultimus*) which comprise 59% and *Polygnathus* (i.e. *Pol. delicatulus* and *Pol. streeli*) reaching 17% of total platform elements. This biofacies is named herein as the bispathodid-polygnathid (*see* Text-fig. 10). Other species, such as *Pseudopolygnathus graulichi, Siphonodella praesulcata*, and *Pandorinellina plumula* compose together 24% of total platform conodonts.

GENERAL REMARKS ON CONODONT BIOFACIES

Some remarks should be added to the previously published, by SANDBERG (1976), SANDBERG & ZIEGLER (1979), SANDBERG & DREESEN (1984), ZIEGLER & SANDBERG (1984b), and SANDBERG & *al.* (1988b, 1989, 1992), Late Devonian ecologic models of conodont distributions within sedimentary environments.

(*i*) The widespread distribution of the genus *Palmatolepis* in the open-shelf environment during the major part of the Frasnian and early Famennian is in a marked contrast to the carbonate platform communities, which were inhabited mainly by the specialized, narrow, smooth or weakly ornamented polygnathids. A subtle balance between palmatolepids and polygnathids is observed, however, at the open-shelf/carbonate platform boundary. Although the maximum abundance of the genus *Palmatolepis* occurred in habitats extending seawardly, off the carbonate platform environment, sparse representatives of that genus are present in the carbonate platform foreslope, but never in the nearshore carbonate platform interior. It is to note, that BEŁKA & WENDT (1992) reported on the presence of palmatolepids within intrabasinal platform environments in the Late Devonian carbonate sequence of Morocco.

(*ii*) Slightly restricted and of low-energy carbonate platform interior, especially the lagoon, was inhabited mainly by the specialized polygnathid communities.

(*iii*) The icriodid fauna have preferably lived in a shallow, but agitated water with a distinct clastic influx, for instance in the carbonate shoal environment.

The final findings of the conodont biofacies study can be summarized as follows.

Major changes of depositional environments induced marked changes in the conodont communities. It seems, therefore, that there is a direct correspondence between the sea-level changes and the conodont biofacies turnovers.

The repeated turnovers of the conodont biofacies, connected with sea-level changes, provide a very strong support for the statement that the majority of Late Devonian conodont-bearing animals were probably nektobenthic in their habit.

DEPOSITIONAL ENVIRONMENT AND ITS HISTORY

The Devonian position of "Old Red Sandstone Continent" (called sometimes Euramerica), composed of Laurentia and the most of northern Europe (called Baltica) is based on the last paleomagnetic data (*see* SCOTESE & McKERROW 1990, Fig. 16; KENT & VAN DER VOO 1990, Fig. 6; TORSVIK & *al.* 1990, Figs 12-13) and is in good agreement with Devonian paleoclimate indicators. According to the Late Devonian paleoclimatic reconstruction by HECKEL & WITZKE (1979, Fig. 4), WITZKE & HECKEL (1988), and WITZKE (1990, Fig. 6) the northern Europe should be placed south to the equator, in latitudes between 10-30°. The widespread occurrence of evaporites (mainly sulphates) associated with red-colored clastic deposits reported from many areas of northern Europe provide proof for such a setting (*see* HECKEL & WITZKE 1979, BLESS & *al.* 1984, PAPROTH & *al.* 1986, THOREZ & DREESEN 1986, WITZKE 1990).

During Late Devonian Epoch the Western Pomerania area was a fragment of an elongated epicratonic sea which surrounded the southeastern side of the "Old Red Sandstone Continent". The late Famennian carbonate, siliciclastic or mixed siliciclastic-carbonate deposits, sometimes called the Condroz-type facies, are known from the northern Devon area, the Velbert area in the Rhine Slate Mountains, the Western Pomerania area in Poland, Lithuania and Latvia in northeastern Europe, the Lublin area in southeastern Poland and from the Ukraine (*see* MATYJA 1988). Outside these areas, generally in a southward direction, the Upper Devonian successions were usually of deep basinal facies types (HOUSE 1975; P. ZIEGLER 1982, 1990). The Western Pomerania area, the Polish fragment of this shallow sea, was bordered to the north and to the east by land mass of the East European Precambrian craton, which was a part of the "Old Red Sandstone Continent" (*cf.* Text-fig. 21 *and* MATYJA 1988, Fig. 5), and sloped southward into a deeper shelf. The hinterland to the north and east consisted of the Fennoscandian and Mazurian (or Byelorussian) lands, the elevated parts of the East European Precambrian craton. These continental areas probably formed more or less continuous land mass during the relatively low stand of sea level (which probably influenced sedimentation by supplying terrigenous material), but during maximum transgression they were probably separated by straits (R. DADLEZ 1978, 1987). Therefore, the recognized Devonian facies pattern within the Pomeranian epicratonic sea depended on aforementioned geotectonic factors as well as on the paleogeographic framework which controlled northward and eastward sea shallowing.

No data exist that would make a reconstruction of Early Devonian facies pattern possible (*see* Miłaczewski 1987, Łobanowski 1990). Marine sedimentation began in the Middle Devonian Epoch. At that time, Western Pomerania seems to have been a large, shallow marine and coastal area which was subject to marine ingressions during Eifelian time. Distinctly marine conditions were established, however, only in Givetian time (R. Dadlez 1978, Miłaczewski 1987).

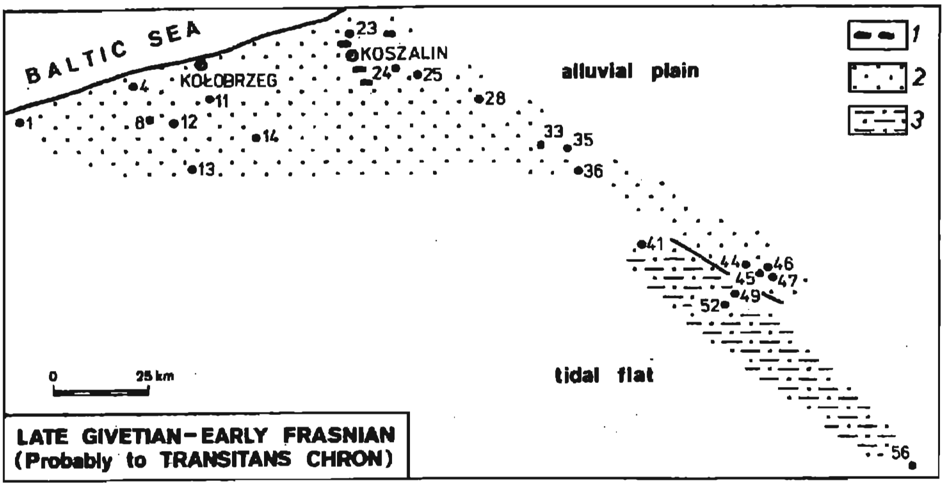

Fig. 11. Lithofacies and conodont biofacies pattern in Western Pomerania during the late Givetian and early Frasnian time (probably up to the *transitans* Chron)

1 — Conglomerates, 2 — sandy lithofacies, 3 — sandy-shale lithofacies

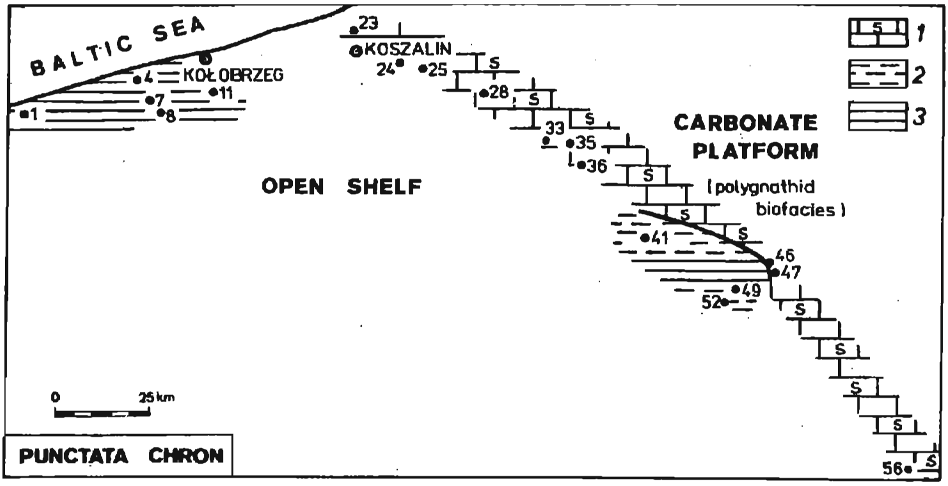

Fig. 12. Lithofacies and conodont biofacies pattern in Western Pomerania during the *punctata* Chron (Frasnian)

1 — Stromatoporoid-coral limestone lithofacies, 2 — marly lithofacies, 3 — shale lithofacies

The early Frasnian alluvial and extremely shallow marine deposits of the Wyszebórz and Chojnice formations (*see* Text-fig. 11) were drowned owing to the rapid Late Devonian transgressive episode, which took place probably at the beginning of the Frasnian *punctata* Chron. In the eastern, more proximal part of the Pomeranian epicratonic sea, an extensive carbonate platform with stromatoporoid-coral limestones (the Koczała Formation) was developed between the Unisław and Jamno areas (*see* Text-fig. 1 for location), close to the East European Precambrian craton margin. In front of the carbonate platform, open shelf marls and shales (the Strzeżewo Member of the Człuchów Formation) were deposited (*see* Text-figs 12-13). These black, fine-laminated, bituminous shales with rare intercalations of marls and marly limestones and a sparse nektic and planktic fauna, almost devoid of benthic fauna, are interpreted as representing rather pelagic sedimentation in a relatively deep, probably dysaerobic or anoxic environment. Within this deeper environment, in front of the carbonate platform margin, isolated elevations were formed by organic buildups of stromatoporoid-coral mud-mound type (the Koczała Formation). The carbonate platform was definitively drowned and covered by deeper open-shelf shales and marls (the Strzeżewo Member of the Człuchów Formation) at the end of the Early *rhenana* Chron. This sedimentary regime persisted over the whole area up to the Famennian Middle *triangularis* Chron (*see* Text-fig. 14).

There is no marked facies turnover at the Frasnian/Famennian boundary (*see* Text-fig. 15). The boundary is, however, accentuated in the analyzed sections by a reduction of the rate of carbonate sedimentation and/or a decrease in the carbonate/clay ratio, as well as by the presence of detrital intercalations in the critical interval.

The transition to the overlying Famennian sediments (the Gorzysław Member of the Człuchów Formation) was rather gradual. The lower Famennian deposits (from the Upper *triangularis* to *rhomboidea* Zone) are characterized by increasing numbers of benthic organisms, a progressive loss of fine lamination and a lighter coloration of the sediments which still represent a deeper open shelf, although better oxygenated environment (*see* Text-figs 15-16).

Massive mudstones of stromatoporoid-coral-crinoid-bryozoan mud-mounds (the Bielica Member of the Człuchów Formation), characteristic of the Early and Late *marginifera* Chrons (*see* Text-fig. 17), were deposited below the wave-base but within the photic zone, as indicated by the dasycladacean nature of palaeoberessellid algae (SKOMPSKI 1987). The Pomeranian mud-mounds developed in a linear northwest-southeast striking arrangement, probably on tectonically controlled intrabasinal highs, connected with the Teisseyre-Tornquist tectonic zone.

The nodular bioclastic limestones and bioclastic grainstones (the Gościno Member of the Człuchów Formation) occurred between the supposed buildups of the mud-mound-type and were deposited in a shallow open shelf environment, generally well-oxygenated and of normal salinity.

The Krojanty and Kłanino formations are successions of very shallow-marine carbonate and siliciclastic-evaporite deposits. They represent an important regressive event which abruptly affected the investigated region with

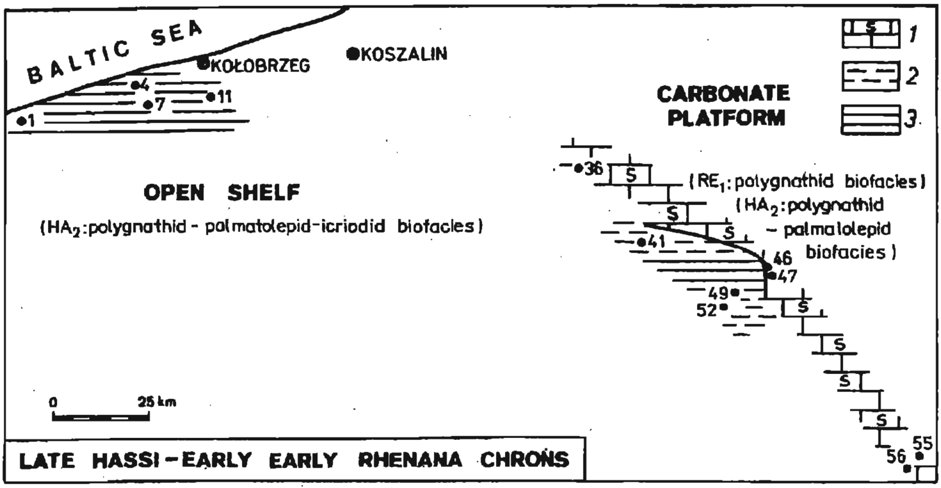

Fig. 13. Lithofacies and conodont biofacies pattern in Western Pomerania during the Late *hassi* — early Early *rhenana* Chrons (Frasnian); *see* Text-fig. 12 for lithofacies key

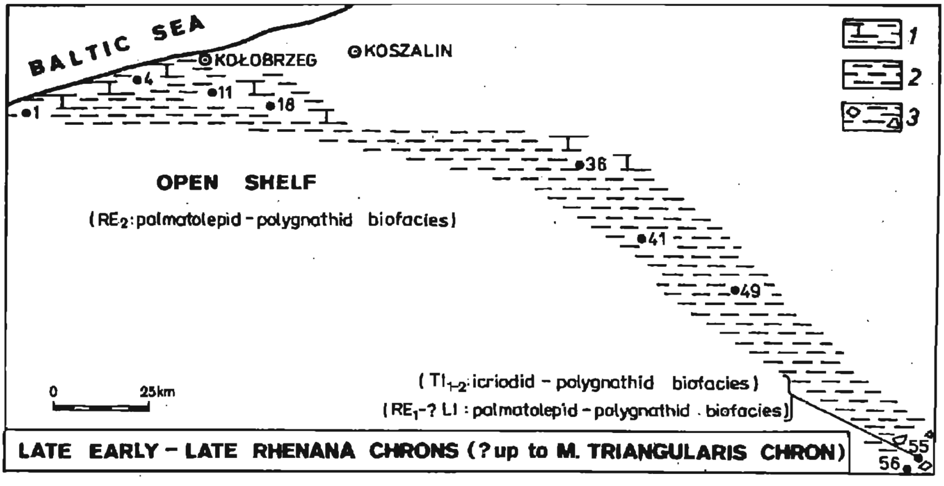

Fig. 14. Lithofacies and conodont biofacies pattern in Western Pomerania during the late Early — Late *rhenana* Chrons (Frasnian; probably up to the Middle *triangularis* Chron)

1 — Marly nodular lithofacies, 2 — marly lithofacies, 3 — marly lithofacies with intraformational conglomerates

the beginning of the Latest *marginifera* Chron, and was reflected by overall progradation to the south of nearshore (tidal flat and carbonate shoal) environments (*compare* Text-figs 17-18 and 19). At that time, it is possible to distinguish several sedimentary environments:

(*i*) Tidal flat connected with the restricted platform interior and characterized by siliciclastic-evaporite sediments rhythmically interlayered with laminated dolostones and lime mudstones (the Klanino Formation), known in the northern part of the investigated area;

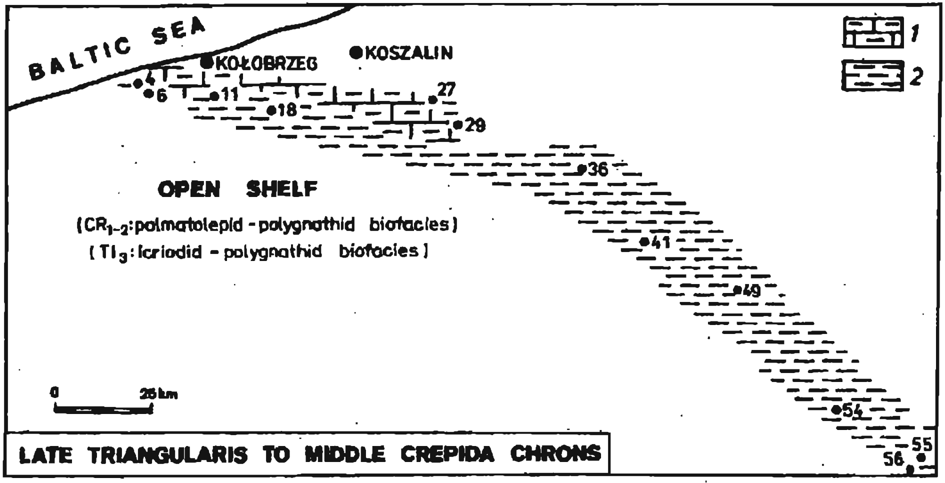

Fig. 15. Lithofacies and conodont biofacies pattern in Western Pomerania since the Late *triangularis* up to the Middle *crepida* Chron (Famennian)
1 — Marly limestone lithofacies, 2 — marly lithofacies

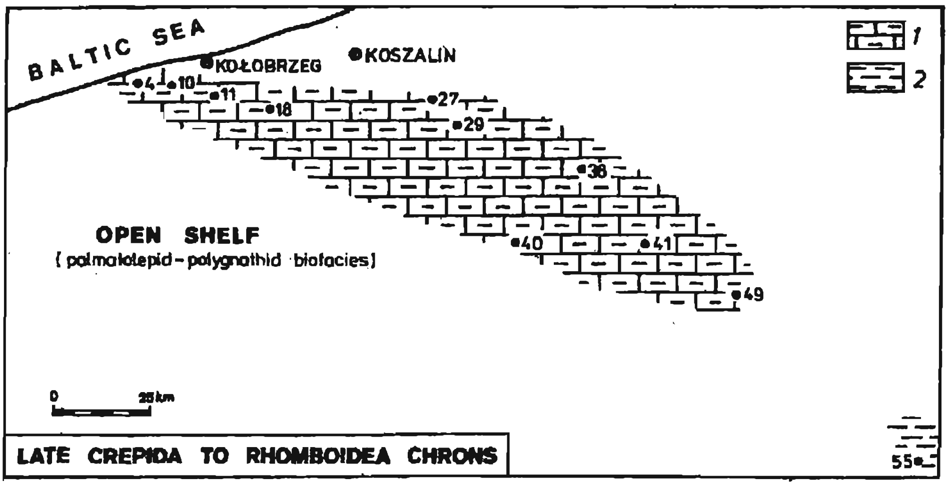

Fig. 16. Lithofacies and conodont biofacies pattern in Western Pomerania since the Late *crepida* up to the *rhomboidea* Chron (Famennian); *see* Text-fig. 15 for lithofacies key

(*ii*) Carbonate sand shoal developed probably at the platform margin (the Kłanino Formation), known only in the northwestern part of the Western Pomerania;

(*iii*) Shallow, slightly restricted environment (probably lagoon) connected with the carbonate platform interior (the Krojanty Formation), mainly known in the eastern and southeastern part of the Western Pomerania.

Laminated dolostones and lime mudstones are interlayered with siliciclastic-evaporite deposits, characterized by flaser, wavy and lenticular bedding. They reflect constantly fluctuating but relatively low energy conditions and allow for the possibility of recognizing tidal processes (*see* SHINN 1983, THOREZ & *al.* 1988). The terrigenous material of unknown origin is characterized by the domination of quartz and the low content of feldspar and heavy minerals. The affinity with granitoid-type rocks suggests that the material comes from the erosion of the East European Precambrian craton.

Of particular interest is the elongated narrow barrier system which separated the depositional environment into back-barrier and more open-marine environment during the Early and Middle *expansa* Chrons. It probably resulted from the current activity which caused the accumulation of the coarser material in the form of a narrow, elongate bar. Reduced circulation within the platform interior induced high environmental stress which was responsible for the restricted colonization with relatively low diversity communities. The presence of crypto- to finely crystalline laminated dolostones, fenestral and thrombolite structures, vermiform gastropods and, in particular, evaporites, points to a sheltered hypersaline environment within a tidal flat area.

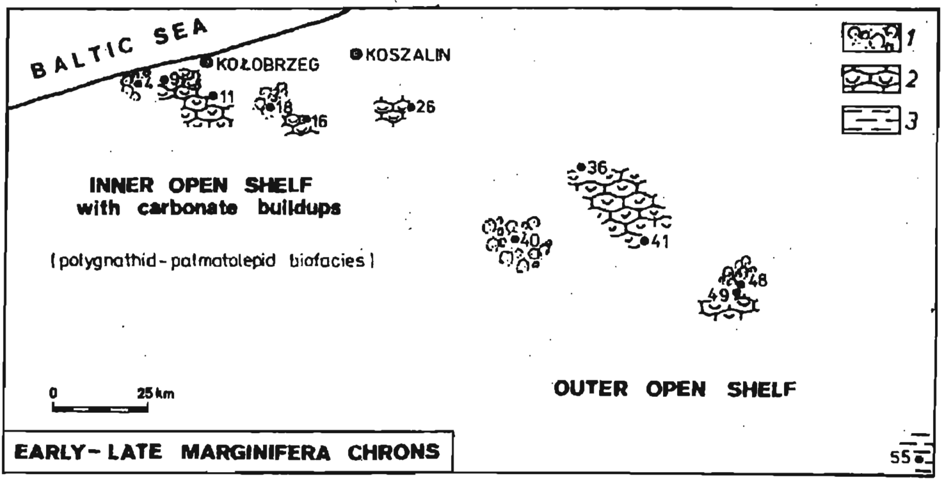

Fig. 17. Lithofacies and conodont biofacies pattern in Western Pomerania during the Early — Late *marginifera* Chrons (Famennian)

1 — Carbonate buildup lithofacies, 2 — nodular limestone (crinoid-brachiopod) lithofacies, 3 — marly lithofacies

In the carbonate platform interior, algal-foraminiferal wackestones and packstones dominated, alternating with bioclastic peloidal grainstones probably of storm origin (the Krojanty Formation). Fossil content as well as sedimentary structures point to shallow but somewhat restricted subtidal, probably lagoon environment.

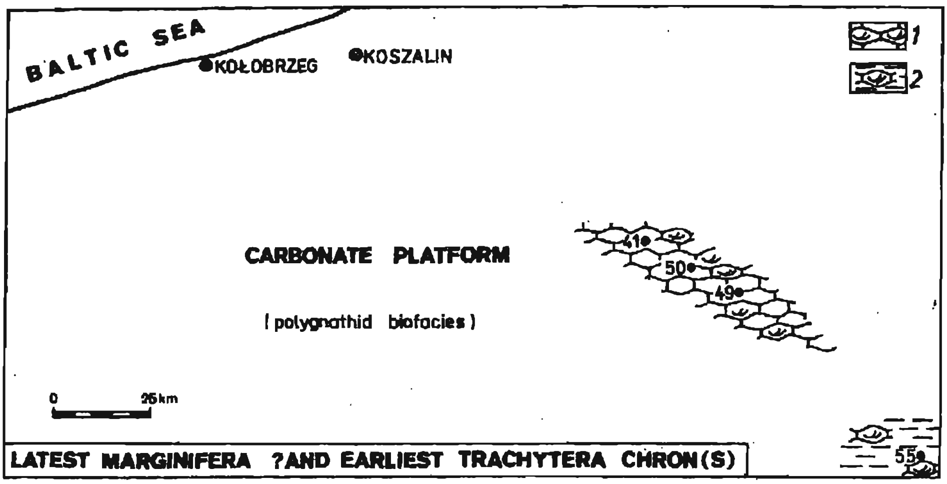

Fig. 18. Lithofacies and conodont biofacies pattern in Western Pomerania during the Latest *marginifera* Chron (Famennian)

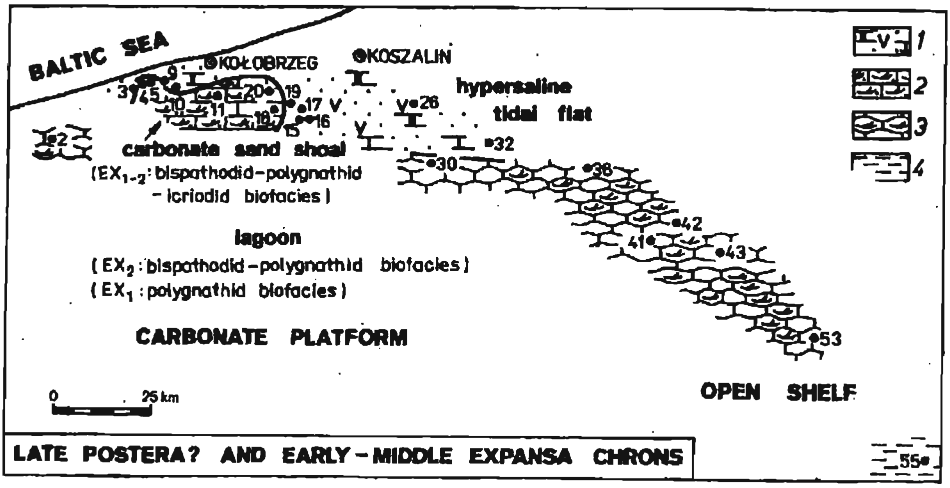

Fig. 19. Lithofacies and conodont biofacies pattern in Western Pomerania during the Late *postera*? and Early — Middle *expansa* Chrons (Famennian)

1 — Carbonate-siliciclastic-evaporite (Condroz type) lithofacies, 2 — cross-bedded detrital limestone lithofacies (algal-foraminiferal-peloidal microfacies with terrigenous quartz admixture), 3 — nodular-detrital limestone lithofacies (algal, algal-foraminiferal and bioclastic-peloidal microfacies), 4 — nodular limestone (brachiopod) lithofacies, 5 — marly lithofacies

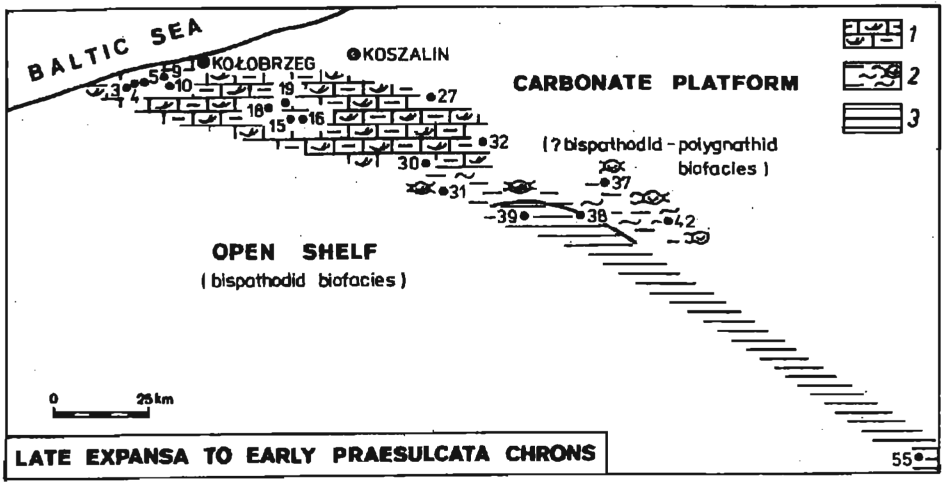

Fig. 20. Lithofacies and conodont biofacies pattern in Western Pomerania during the Late *expansa* — Early *praesulcata* Chrons (Famennian)

1 — Marly limestone lithofacies (mainly agglutinated foraminiferal-algal microfacies), 2 — marly lithofacies, 3 — shale lithofacies

At the end of Devonian, beginning with the Late *expansa* Chron, an open shelf environment become prevalent almost over the whole Western Pomerania area (*see* Text-fig. 20) and persisted to the early Tournaisian (the Sąpolno Formation).

There are rather clear trends in the pattern of Upper Devonian facies in Western Pomerania through time. During the Late Devonian Epoch Western Pomerania underwent evolution from an extremely shallow water and coastal environments in the earliest Frasnian, through deeper environments during the rest of the Frasnian and early Famennian, up to the reappearance of shallow water and coastal environments in the late Famennian time (*see* Text-fig. 21), since the Latest *marginifera* Chron up to the Middle *expansa* Chron. At the end of the Famennian, beginning with the Late *expansa* Chron, an open shelf environment became prevalent almost over the whole area and continued up to the early Tournaisian time.

EVENT STRATIGRAPHY

The event stratigraphy is one of the stratigraphic research method that incorporates all available biotic and abiotic data to achieve more reliable and precise time correlations, and to demonstrate the coincidence in timing of well-dated deepening and shallowing traits in different sedimentary basins. The synchroneity of these events indicates their control by eustatic sea-level fluctuations rather than by local or regional epeiric movements.

In practice, evidence of abrupt lithologic changes obtained from a single section, as well as facies shifts detectable in multiple sections, both combined by applying Walther's law, provide information for changes in apparent sea-level fluctuations. It is a relative sea-level depth indicated by the position of beds in a sequence rather than any absolute depth indicator. Deepening events are indicated among others by a base of subtidal shales over carbonate platform rocks, a base of sedimentary rocks above unconformities, as well as by inceptions of carbonate buildups growth (*see* Johnson & *al.* 1985, 1986).

The rapidly fluctuating disruptions in oceanic temperature, chemistry, circulation or stratification, measured through stable isotope and rare element geochemistry, were associated with most global biotic crises of differentiated nature, involving mortality, extinction and adaptative radiation (*see* House 1985, 1989). Therefore, well-dated turning points in sedimentary development, as well as different biotic events, both occurred in response to sea-level fluctuations, may make good markers in interregional correlations (*see* Dreesen 1987).

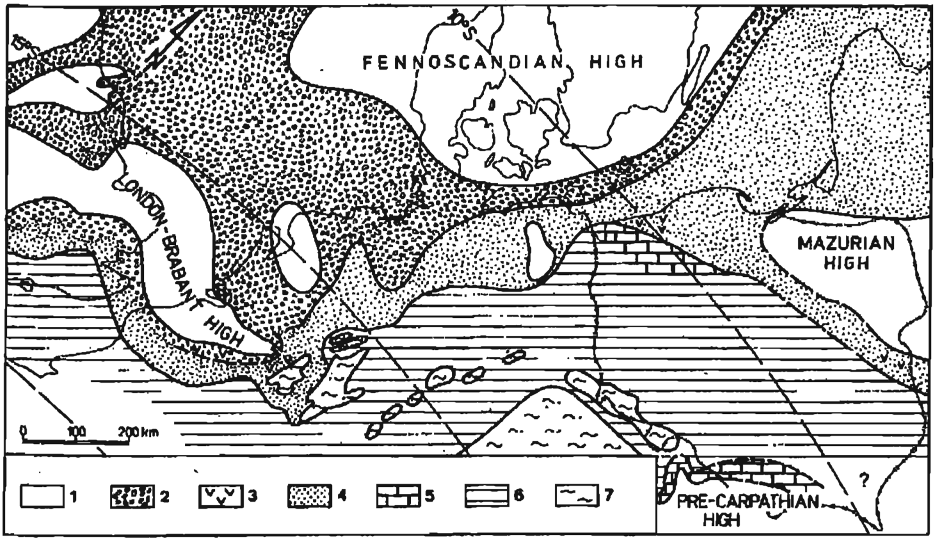

Fig. 21. Late Famennian paleogeography of Western and Central Europe (simplified *after* P. Ziegler 1982, 1987; Paproth, Dreesen & Thorez 1986), modified in the Polish part to comply with the results of the present study

1 — Non-depositional area, 2 — multistory alluvial facies on continental lowlands, 3 — evaporites, 4 — shallow siliciclastic or mixed carbonate-siliciclastic (Condroz-type) facies, 5 — carbonate platform facies, 6 — open-shelf facies, 7 — submarine shoals

Among major Devonian bioevents (*see* House 1985, 1989; Ziegler & Lane 1987), the Kellwasser Event at the end of the Frasnian, and the Hangenberg Event at the end of Famennian have received the most high-resulting analyses (*see* McLaren 1982, Narkiewicz & Hoffman 1989, Geldsetzer & *al.* 1987, Sandberg & *al.* 1988b, Brand 1989, Szulczewski 1989, WALLISER & *al.* 1989, SCHINDLER 1990, BUGGISCH 1991, WENDT & BEŁKA 1991, BEŁKA & WENDT 1992, MATYJA & NARKIEWICZ 1992b) and were related to global anoxic events with subsequent ocean overturn, Other Late Devonian bioevents, *i.e.* the Nehden Event at the end of the *triangularis* Chron, the Enkeberg Event within the Early *marginifera* Chron, and the Annulata Event at the beginning of the *postera* Chron (*see* HOUSE 1985, 1989 *and* Text-fig. 22 in this paper), are still not satisfactorily recognized.

The Late Devonian event stratigraphy of Western Pomerania is interpreted through the conodont biofacies analysis (*see* Text-figs 9-10), as well as

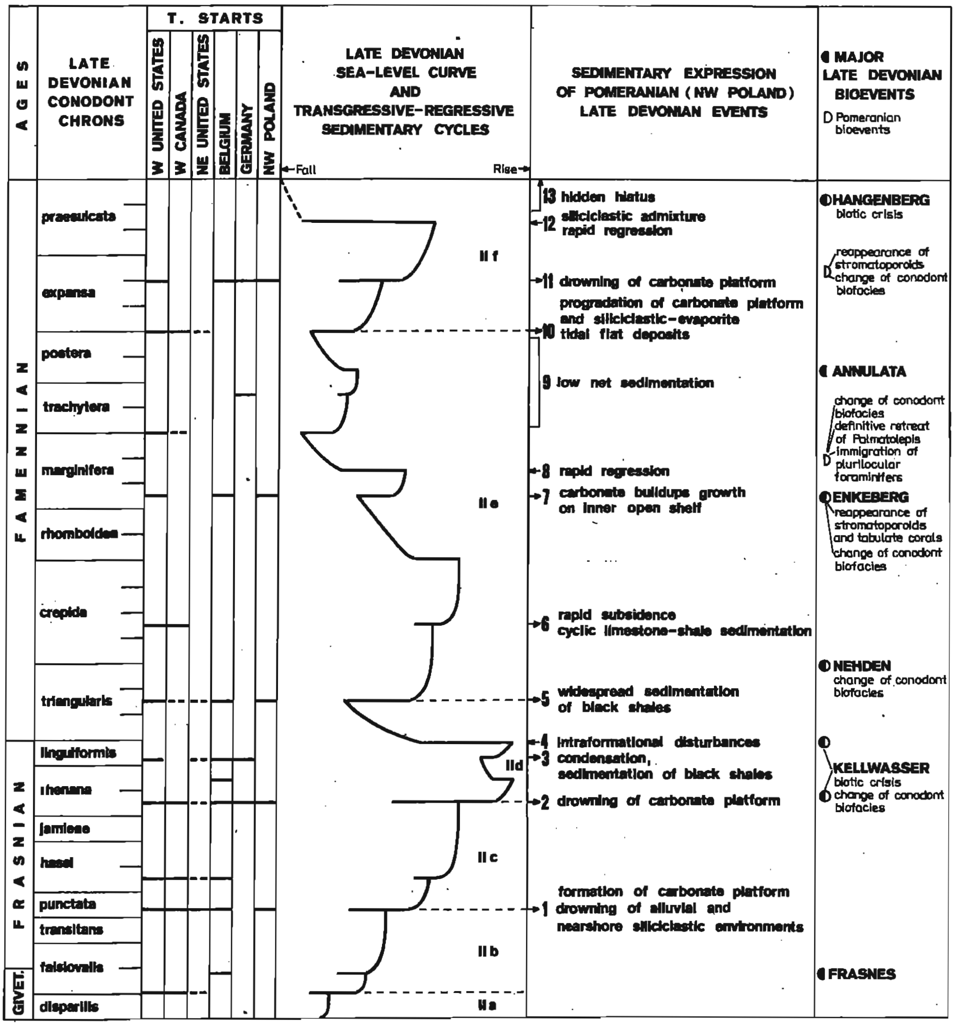

Fig. 22. Late Devonian events in Western Pomerania (NW Poland); major Late Devonian bioevents *after* HOUSE (1985, 1989); Late Devonian sea-level curve and transgressive-regressive sedimentary cycles *after* JOHNSON, KLAPPER, & SANDBERG (1985); JOHNSON & SANDBERG (1989); SANDBERG, W. ZIEGLER, DREESEN & BUTLER (1992)

the analysis of litho- and biofacies succession and distribution (*see* Text-figs 11-20). The presented maps portray relatively short time slices that were chosen to depict the most significant environmental changes produced by major rises and falls of sea level.

A sequence of 13 events, both eustatic sea-level changes (*see* HOUSE 1983; JOHNSON & *al.* 1985, 1986; JOHNSON & SANDBERG 1989) and epeiric movements, as well as those of the biotic nature (*see* HOUSE 1985, 1986), is revealed and dated in terms of the worldwide standard conodont zonation (*see* Text-fig. 22). Its precision is limited to the spantime of a single conodont zone, lasting generally about 0.5 m.y. (*see* SANDBERG & *al.* 1988).

Event 1: *PUNCTATA* SEA-LEVEL RISE

Middle Devonian and the Frasnian coastal and extremely shallow-water marine siliciclastic deposits (Wyszebórz and Chojnice Formations) were drowned and covered by carbonate platform deposits (the Koczała Formation) in the east, as well as by offshore shales (the Strzeżewo Member of the Człuchów Formation) in the north- and southwest (*compare* Text-figs 8, 11 and 12). This deepening event took place within the *punctata* Chron and was possibly eustatic. It was synchronous with the beginning of the *T-R cycle IIc* of JOHNSON & *al.* (1985, 1986) and contemporaneous with the drowning of the Middle Devonian biostromal platform in southern Poland (*see* SZULCZEWSKI 1971, NARKIEWICZ 1988), with the growth of the first level of Frasnian buildups in Belgium, as well as with the sea-level rise observed in the western United States and in Canada (*see* SANDBERG & *al.* 1983; JOHNSON & *al.* 1985, 1986; JOHNSON & SANDBERG 1988; SANDBERG & *al.* 1988).

Event 2: EARLY *RHENANA* SEA-LEVEL RISE

Early Frasnian carbonate platform was drowned and the whole Western Pomerania area was covered by offshore shales (*compare* Text-figs 8, 13 and 14) within the Early *rhenana* Chron. This transgressive event is readily detectable in all sections where the carbonate-platform deposits occurred (the Koczała Formation). In some sections situated offshore of the carbonate platform, the resulting open shelf lithofacies (the Gorzysław Member) are similar to those predating the transgressive pulse (the Strzeżewo Member). The lithofacies change coincides with a turning point in a biofacies sequence that runs from the shallow-water polygnathid biofacies connected with the carbonate platform interior to the deep-water palmatolepid-polygnathid one characteristically indicating open-shelf environments (*see* Text-figs 9-10, 12-14 and 22).

The Early *rhenana* transgressive event is synchronous (*see* Text-fig. 22) with the beginning of the *T-R cycle IId* of JOHNSON & *al.* (1985) and it represents the greatest Late Devonian eustatic rise. The onset of the transgression is marked in numerous sections worldwide (*see* NARKIEWICZ 1988 for short overview) and it caused volumetric decline of Frasnian reef-building organisms (*see* SANDBERG & *al.* 1988, JOHNSON & SANDBERG 1988). This global event is known as the Early Kellwasser Event.

Event 3: EARLY *LINGUIFORMIS* SEA-LEVEL RISE

Event 4: LATE *LINGUIFORMIS* SEA-LEVEL FALL

There is no marked facies turnover at the end of the Frasnian and the whole area of Western Pomerania was covered by open shelf sediments (*see* Text-fig. 15). The critical interval near the *linguiformis/triangularis* zonal boundary displays two lithological features, however, that may be related to the Frasnian/Famennian boundary event: (*i*) reduction in a rate of carbonate sedimentation and/or a decrease in the carbonate to clay ratio within the Frasnian latest *rhenana*, *linguiformis* and Famennian *triangularis* Chrons; (*ii*) increased percentage of intraformational conglomerates upward the sections within the late *linguiformis* and Early-Middle *triangularis* Chrons. Most of the clasts represent shallow nearshore carbonate environments. The coarse-grained deposits which evidence an intraformational erosion, correspond to the regressive and/or epeiric event.

There is also a clear change in conodont faunas near the boundary between the *linguiformis* and *triangularis* Zones, comparable with the shift in conodont biofacies described by SANDBERG & *al.* (1988b) from the latest *linguiformis* Chron. In general, a drop in deep-water *Palmatolepis* abundance is observed, accompanied by the increase in moderately shallow-water *Icriodus* frequency, as well as the disappearance (extinction event) of the genus *Ancyrodella*. Moreover, the conodont biofacies changed from the deeper palmatolepid-polygnathid in the *linguiformis* Chron to the shallower and mixed palmatolepid-icriodid one in the Early *triangularis* Chron (*see* MATYJA & NARKIEWICZ 1992b).

The observed changes, both lithologic as well as within the conodont communities (*see* Text-fig. 22), are comparable to the results of SANDBERG & *al.* (1988b) who envisaged a eustatic rise within the early *linguiformis* Chron followed by an abrupt eustatic fall within the late *linguiformis* Chron, and who interpreted these events responsible for the extinction event soonafter the onset of the regression. The discussed Frasnian/Famennian biotic crisis is known as the Late Kellwasser Event, during which mass extinction in many fossil groups occurred (*see* BUGGISCH 1991, for overview).

Event 5: MIDDLE *TRIANGULARIS* SEA-LEVEL RISE

The regressive tendency was reversed in Western Pomerania within the Middle *triangularis* Chron and the whole area underwent sedimentation of black shales (*see* Text-figs 3-4). This deepening event was synchronous with the beginning of the *T-R cycle IIe* of JOHNSON & *al.* (1985) and contemporaneous with a deepening event of eustatic nature observed in the western and northeastern United States, western Canada as well as in Belgium (*see* JOHNSON & *al.* 1985, 1986; JOHNSON & SANDBERG 1988; SANDBERG & *al.* 1988).

The lower Famennian deposits, from the Upper *triangularis* up to the *rhomboidea* Zone, still represent a deeper open-shelf environment (*see* Text-figs 15-16). Although there is no distinct facies turnover at the end of the *trangularis* Chron, a clear change of conodont biofacies is observed between the *triangularis*/*crepida* Chrons from the relatively shallow-water icriodid-polygnathid biofacies to the deep-water palmatolepid-polygnathid one (*see* Text-fig. 9). It is thought that this bioevent was connected with the Nehden Event of HOUSE (1985, 1989; *see also* Text-fig. 22 in this paper).

Event 6: MIDDLE (OR EARLY) *CREPIDA* SEA-FLOOR SUBSIDENCE AND CYCLIC LIMESTONE-SHALE SEDIMENTATION

The event which took place within the Middle (or within the Early) *crepida* Chron, is characterized by a tectonically controlled rapid subsidence of sea-floor, as well as by the beginning of the cyclic limestone-shale sedimentation. This typical anaerobic deeper shelf lithofacies is very similar to dark laminated shales with some intercalations of lime mudstones which are very characteristic of the Bychawa Formation in the Lublin area (MIŁACZEWSKI 1981).

This event, although partly connected with epeiric movements, is contemporaneous (*see* Text-fig. 22) with one of the transgressive pulse of the *T-R cycle IIe*, observed in the western United States (*see* SANDBERG & *al.* 1988).

Event 7: EARLY *MARGINIFERA* SEA-LEVEL RISE

Prominent regressive tendencies were observed in the investigated area over a prolonged period of time, beginning from the end of *crepida* Chron (*see* Text-figs 8 and 16) up to the Middle *expansa* Chron (*see* Text-figs 8, 18-19 and 22). The prolonged *T-R cycle IIe* regression was reversed, however, by the deepening event in the Early-Middle *marginifera* Chron.

During the short-term transgressive pulse the carbonate buildups were formed on tectonically controlled submarine highs. Tabulate corals and ramose stromatoporoids were found within these carbonate buildups, confirming an idea of the persistence of stromatoporoid-coral buildups into the late Famennian, *i.e.* distinctly after the Frasnian reef extinction event (*see* Dreesen & *al.* 1985, Hladil & *al.* 1991). The Early-Middle *marginifera* Chron transgressive pulse resulted also in the immigration of primitive plurilocular foraminifers.

Immigration of tabulate corals, stromatoporoids and plurilocular foraminifers is contemporaneous with a significant rise of sea level recognized in the Holy Cross Mountains (Szulczewski 1992), in Belgium — formation of the Baelen mudmounds (Dreesen & *al.* 1985), as well as on the western United States platforms (Johnson & *al.* 1985, Sandberg & *al.* 1988), although this transgression is not recorded as eustatic (Johnson & *al.* 1985). The observed bioevent is also contemporaneous with Enkeberg Event (*see* House 1985, 1989) which as yet, is well described only from a locality at Enkeberg, Germany, where *Cheiloceras* became extinct, and the Clymeniina appeared for the first time (*see* House 1985).

Event 8: LATEST *MARGINIFERA* RAPID SEA-LEVEL FALL

A strong regressive event, reflected by overall progradation of nearshore environments to the south and southwest, abruptly affected the Pomeranian epicratonic sea at the beginning of the Latest *marginifera* Chron (*see* Text-figs 8, 17-18). The conodont biofacies changed from the relatively deeper polygnathid-palmatolepid during the Early-Late *marginifera* Chrons to the very shallow-water polygnathid one in the Latest *marginifera* Chron (*see* Text-fig. 10). This bioevent was related with the definite retreat of the offshore genus *Palmatolepis* from the Pomerania sea at the end of the *marginifera* Chron (*see* Text-fig. 22), and it was probably still connected with the Enkeberg Event of House (1985).

Event 9: *TRACHYTERA-POSTERA* ?NON-DEPOSITIONAL GAP

It is not certain whether a hiatus exists between the Latest *marginifera* Chron and Early *expansa* Chron or whether the deposition was more or less continuous, taking into account a low net sedimentation possibly falling on the *trachytera* and *postera* Zones. Possibly, the sea-level fall, which was probably accompanied by epeiric uplifts produced an erosional episode that affected the entire Western Pomerania, and caused erosion of older rocks.

Regional unconformities recognized in the late Famennian of the western United States and Canada encompass similar stratigraphic interval, *i.e.* Latest *marginifera* Chron and the whole *postera* Chron (Sandberg & Poole 1977; Sandberg & *al.* 1983, 1988; Johnston & Chatterton 1991). It should be noted that this Event is contemporaneous with the regression that ended the *T-R cycle IIe* of Johnson & *al.* (1985).

Event 10: EARLY *EXPANSA* SEA-LEVEL RISE

In the beginning of the Early *expansa* Chron (after an ?erosional event) the area of Western Pomerania was onlapped by nearshore carbonate platform as well as siliciclastic-evaporite tidal-flat deposits in the north and northeast, whereas in the southeast open-shelf sediments were deposited (*see* Text-fig. 19). During the Early-Middle *expansa* Chrons minor regressive tendencies are observed, manifested by south- and soutwestward progradation of the carbonate-platform and siliciclastic-evaporite deposits.

The discussed Early *expansa* transgressive event is synchronous with the beginning of the *T-R cycle IIf* of Johnson & *al.* (1985).

Event 11: LATE *EXPANSA* SEA-LEVEL RISE

Very shallow-water, nearshore environments, which existed from the Latest *marginifera* up to the Middle *expansa* Chrons, were drowned in the Late *expansa* Chron when the area of Western Pomerania was covered by offshore shales in the south and southeast, as well as by marly fossiliferous limestones connected with a carbonate-platform foreslope in the north and east (*compare* Text-figs 19 and 20).

The change of the conodont biofacies is not very distinct between the Middle and Late *expansa* Chrons (*see* Text-fig. 10). The bispathodid-polygnathid biofacies still prevailed in the Late *expansa* Chron, but it was composed mainly of ubiquitous forms, in comparison with the Middle *expansa* Chron biofacies where many shallow-water polygnathid species occurred.

It is to note that stromatoporoids reappeared to the Pomerania sea twice during the Famennian.

This event is synchronous with the transgressive pulse within the *T-R cycle IIf*, known also from the western United States, as well as from Belgium and Germany (*see* Johnson & *al.* 1985).

Event 12: MIDDLE *PRAESULCATA* SEA-LEVEL FALL

Although there is no marked facies turnover within the Middle *praesulcata* Chron (*see* Text-figs 3-4), regressive siltsones with plant detritus are observed in all sections, synchronous with eustatic sea-level fall that closed the *T-R cycle IIf* and occurred as the final fall which ended the Devonian Period (*see* Johnson & *al.* 1985, 1986; Sandberg & *al.* 1988).

Event 13: MIDDLE *PRAESULCATA-SANDBERGI* HIDDEN HIATUS

The early Middle *praesulcata* Chron regression was followed by stillstand or minor onlaps through the Famennian Middle *praesulcata* – Tournaisian *sandbergi* Chrons. No distinct facies turnover is observed during this time interval, although a stratigraphic gap and the development of condensed sequence is observed in all investigated sections. The only physical manifestation of the sedimentological disturbances within the monotonous and unfossiliferous shale deposits of almost pelagic nature above the Devonian Middle *praesulcata* and below the Carboniferous *sandbergi* Zone, is the presence of pyrite as well as the occurrence of rich organic matter. No surfaces with peculiar microrelief, which might be an evidence of corrosion, have been found. Moreover, there is no evidence of any pre-*sandbergi* abrasion affecting the Famennian and Tournaisian deposits observed in some sections in southern Poland (*see* Szulczewski 1973, 1978; Bełka 1985). Presumably, this stratigraphic gap resulted from some chemical or hydrodynamical factors rather than from any tectonic uplift.

It was probably a submarine nondeposition gap which was an effect of a strong decrease or even cessation of lime-mud production for a long time. If this is the case, however, the absence of conodonts of two Devonian and two Carboniferous zones is hard to explain. One would expect, rather, an increased abundance of conodonts as a consequence of the low accumulation rate. One explanation is that conodonts and other faunal remains could have been mechanically washed out or, which is more probable, unfavorable changes in water chemistry and/or water stratification might have led to a long-term stress and retreat of all faunal groups from the Pomeranian sedimentary basin.

The presented event corresponds to the euxinic black shale event which affected many places worldwide, known as the Hangenberg Event (*see* House 1985), which is probably responsible for a decline and extinction of many faunal groups at the end of the Devonian and is often comparable with the Kellwasser Event at the end of the Frasnian.

* * *

All the above-recognized events, though differently manifested in various depositional environments and usually short-termed, seem to be an excellent stratigraphic tool which enables precise time-correlation between distant and facially differentiated sequences.

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H. MATYJA

GÓRNY DEWON POMORZA ZACHODNIEGO

(Streszczenie)

Przedmiotem pracy jest stratygrafia konodontowa i rozwój facjalny utworów franu i famenu oraz odtworzenie sekwencji zdarzeń w późnym dewonie w obrębie epikratonicznego zbiornika morskiego obszaru dzisiejszego Pomorza Zachodniego.

W obrębie generalnie węglanowej, jak również mieszanej węglanowo-silikoklastycznej sekwencji osadów górnodewońskich, zbadanej w ponad 50 głębokich profilach wiertniczych (*patrz* fig. 1-4 oraz pl. 1-16), wyróżniono 5 nieformalnych jednostek litostratygraficznych o randze formacji oraz 4 o randze ogniwa. Poczynając od najstarszych, są to: formacja koczalska, częściowo zazębiająca się z nią formacja człuchowska (w obrębie której wyróżniono 4 ogniwa — strzeżewskie, gorzysławskie, gościńskie i bielickie), formacja krojancka i zazębiająca się z nią formacja kłanińska, oraz najmłodsza formacja sąpolniańska (*patrz* fig. 8).

Analiza biostratygraficzna pozwoliła na wyróżnienie 21 standardowych poziomów konodontowych, od frańskiego poziomu *punctata* poczynając, a na turnejskim poziomie *sandbergi* kończąc (*patrz* fig. 5-7, tab. 1-14 oraz pl. 17-36). Ustanowiono 4 nowe gatunki konodontów: *Polygnathus limbatus* sp. n., *Polygnathus pomeranicus* sp. n., *Polygnathus praecursor* sp. n. oraz *Alternognathus costatiformis* sp. n.

W obrębie późnodewońskich środowisk sedymentacyjnych rozpoznano oboczne zróżnicowanie lito- i biofacji, jak również ich następstwo w czasie (*patrz* fig. 9-20). Wyróżniono szereg biofacji konodontowych, spośród których najistotniejsze są: palmatolepidowo-polignatidowa, polignatidowo-palmatolepidowa, ikriodidowo-polignatidowa, polignatidowa, polignatidowo-bispatodidowa oraz bispatodidowa. Stwierdzono, iż rozkład i rozprzestrzenienie późnodewońskich lito- i biofacji w epikratonicznym morzu dzisiejszego Pomorza Zachodniego uzależnione były ściśle od położenia tego obszaru w pobliżu krawędzi kratonu wschodnioeuropejskiego (*patrz* fig. 21).

We wczesnym franie obszar Pomorza Zachodniego usytuowany był wśród ekstremalnie płytkowodnych i przybrzeżnych środowisk sedymentacyjnych. W ciągu niemal całego franu i wczesnego famenu mieścił się on natomiast w głębszych środowiskach morza otwartego. Gwałtowny powrót do płytkomorskiej, węglanowo-silikoklastycznej sedymentacji nastąpił pod koniec doby *marginifera* i trwał aż do środkowej doby *expansa*. Pod koniec famenu, poczynając od późnej doby *expansa*, na obszarze Pomorza Zachodniego zapanowały ponownie warunki morza otwartego.

Wyróżniono i opisano następstwo 13 zdarzeń geologicznych (*patrz* fig. 22) o zróżnicowanej naturze, a związanych bądź z eustatycznymi wahaniami poziomu morza, z ruchami epejrogenicznymi, bądź też zmianami natury biotycznej.