ORDOVICIAN CONODONT BIOSTRATIGRAPHY OF THE POLISH PART OF THE BALTIC SYNECLISE

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Ordovician lithostratigraphic units distinguished in the subsurface of the Polish part of the Baltic syneclise were dated by means of conodonts. The oldest Ordovician deposits, ranging from the (?)upper part of the *Cordylodus proavus*(?) Zone to the *C. angulatus* Zone (the top part of the Piaśnica Formation) were penetrated in offshore boreholes. On land, the Ordovician starts with the *Drepanoistodus deltifer–Paroistodus proteus* zones (the Gardno Formation) (with stratigraphic gap) or with the *Oepikodus evae* or *Baltoniodus navis* zones (the Klewno Formation). Because of their lithologic and faunistic similarities, the overlying formations (Słuchowo, Pieszkowo, Sasino) can be correlated with the lithostratigraphic and biostratigraphic units of the southern part of Sweden (Scania and Västergötland) thus indicating a common history of both parts of the sedimentary basin. The Ordovician ends with the *Mucronaspis mucronatus* trilobite zone. Possible equivalents of the *Glyptograptus persculptus* Zone have been identified only in one borehole so far. Local stratigraphic gaps within the Kaszuby Formation are a result of the Taconian synorogenesis. They correspond to the Upper Ashgill (Hirnantian), and separate the sandy limestone (the Kokoszki Member) and the claystone (western part) from the nodular limestone (eastern part) of Llandovery age.

Key words: Conodonta, lithostratigraphy, biostratigraphy, Ordovician.

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INTRODUCTION

In the Polish part of the Baltic syneclise one can distinguish three platform facies belts (Fig. 1). The central platform facies consists of red and grey carbonates and extends across the Baltic Syneclise to Gdańsk Bay in the west and to the central part of the Podlasie Depression in the east. This facies corresponds to the Central Baltoscandian confacies belt (JAANUSSON 1976). The eastern platform facies consists of grey carbonates and is recognized in the easternmost part of Poland including the Suwałki Lake district and the eastern part of the Podlasie Depression. This facies corresponds to the Lithuanian confacies belt. In the Łeba area, in the most western part of the Baltic Syneclise (BEDNARCZYK 1979; PODHALAŃSKA 1980) and in the Warsaw basin, one can distinguish the western platform facies of black bituminous clays. It corresponds to the Scanian confacies. Along the south-western margin of the East-European Craton, the platform facies interfinger laterally with the deep basin facies of the graptolite-bearing claystone belt (BEDNARCZYK 1974).

Materials. — The conodonts found by the present author in the sections of the Baltic Syneclise represent successive conodont zones which are known from Sweden (LINDSTRÖM 1971; LÖFGREN 1978, 1993; BERGSTRÖM 1971). The analized material includes the cores from 15 boreholes drilled by the Polish Oil Company, as well as the lowermost Ordovician samples from the Gdańsk IG 1 borehole. The analysis is based on 10 selected cores only. A detailed biostratigraphic description including taxonomic treatment of the entire material will be presented elsewhere.

Laboratory treatment of the samples. — The samples from several sections were treated with a buffered acetic or formic acid and washed through a 75 μm sieve. The residue was separated mainly by magnetic separation. Especially rich conodont material was found in the red or greenish-grey limestones of the Pieszkowo Formation.

Thermal alteration. — The conodonts are practically unaltered thermally (CAI 1 to 2; see EPSTEIN *et al.* 1977) in the central part of the Baltic syneclise but more altered (CAI 3 to 5) in the western part (Łeba area).

Repository. — The conodonts ilustrated are deposited in the BEDNARCZYK's collection (WB100–WB139), Institute of Geological Sciences, Polish Academy of Sciences, Warszawa, Twarda 51/55, Poland.

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LITHOSTRATIGRAPHY

In marine offshore sections of the Baltic Syneclise the Ordovician begins with a black claystone unit (up to 8.5 m thick) containing numerous graptolites and conodonts (MODLIŃSKI *et al.* 1994). The units represents the uppermost part of the Piaśnica Formation (Fig. 3; HEINSALU and BEDNARCZYK 1997). In the onshore area of the Baltic Syneclise (the Łeba area), the Middle and Upper Ordovician deposits were first subdivided into three formations (PODHALAŃSKA 1980). Later on, in the more offshore part of the syneclise, the Ordovician deposits were subdivided into six formations; including six members (Fig. 3; BEDNARCZYK 1995, 1996).

The sequence starts with an up to 2 m thick claystone with glauconitic limestone intercalations in the Łeba area, partly, Gdańsk area (Gardno Formation) or, elsewhere in the Baltic syneclise, an up to 2.5 m thick glauconitic sandstone (Klewno Formation); Fig. 2. The succeeding grey-green marly claystone of the Słuchowo Formation is 15.0 m thick. It is present in the Łeba area (BEDNARCZYK 1979) and extends to the Gdańsk Depression, where it is thinnest (0.8 m).

The overlying limestone of the Pieszkowo Formation consists of the following four members (Fig. 3): (i) the Kopalino Member which consists of grey or beige marly micritic limestones (calcilutite), locally with nodular structure ranging in thickness from 4.2 in the Gdańsk area to about 20 m in the Łeba area; (ii) the Łankiejmy Member which consists of cherry-brown nodular biomicritic limestones (calcilutite or calcarenite) from 9.7 m to 29.4 m thick; (iii) The Kielno Member which consists of the greenish-grey marly limestones (calcilutite) from 8 m up to 26 m thick; and (iv) Aniołowo Member which occurs locally, consists of light-grey or greenish-grey limestones with numerous brown iron ooliths and bentonite intercalations (from 3.6 m to about 16 m thick) and commonly begins with a thin layer of conglomerate

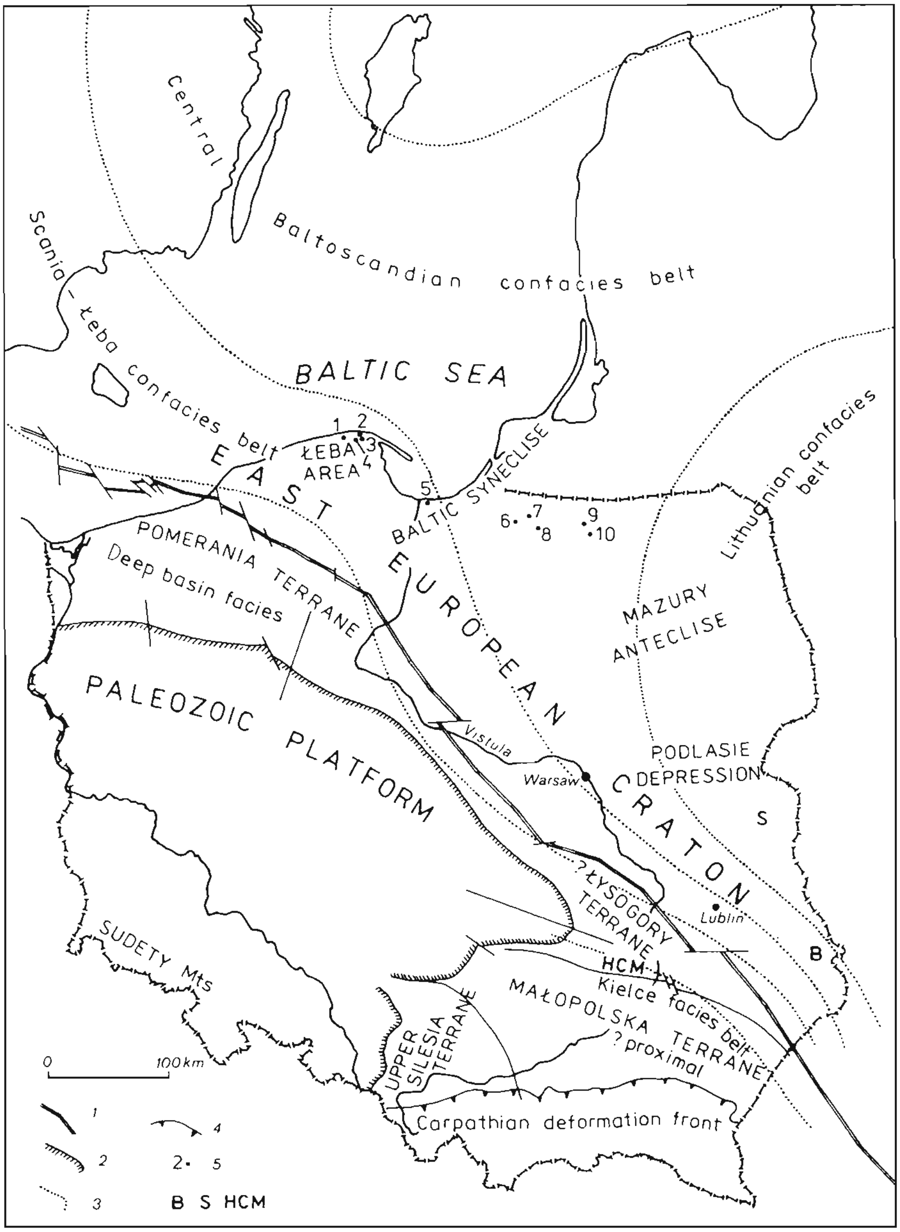
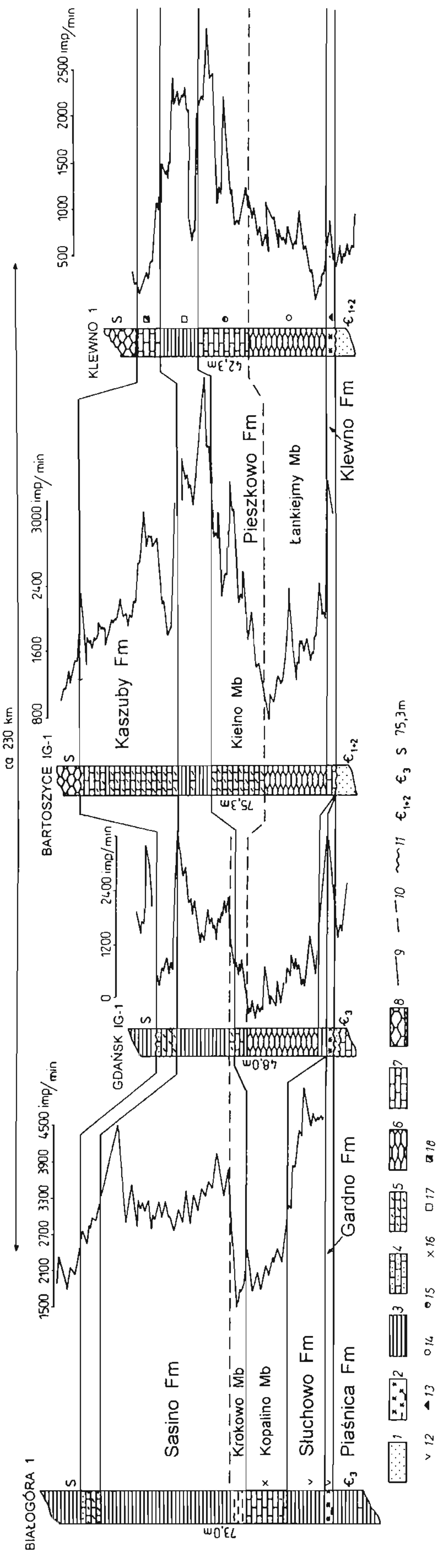


Fig. 1
A structural map of Poland with distribution of Ordovician confacies belts in Poland and the location of boreholes mentioned in this paper. Compiled from BEDNARCZYK 1968, MODLIŃSKI 1982, POŻARYSKI *et al.* 1992, and FRANKE 1994. Abbreviations: 1 – Białogóra 1, 2 – Dębki 2, 3 – Dębki 3, 4 – Piaśnica 2, 5 – Gdańsk IG 1, 6 – Henrykowo 1, 7 – Rodnowo 1, 8 – Łaniewo 1, 9 – Łankiejmy 1, 10 – Klewno 1, a – margin of East European Craton, b – Variscan Deformation Front, c – boundaries of confacies belts, d – boundary of Carpathian Fore-Deep, 2. – borehole, B – Bug Depression, S – Sławatycze Horst, HCM – Holy Cross Mountains.

consisting of grey-green limestone (calcirudite) cemented by a dark-grey marl with numerous iron ooliths. The overlying graptolitic claystone of the Sasino Formation (Figs 2, 3) contains intercalations of crystalline limestone and bentonite. The thickness of the Sasino Formation is from about 43 m in the western part of the Baltic Syneclise to 3.4 m in its central part. The lower part of the formation consists of grey marls or marly claystones (the Krokowo Member). The overlying Kaszuby Formation consists of grey or light-grey marls and marly limestones (calcilutite). The upper part of the formation contains mudstone or sandy limestone layers (Kokoszki Member); Fig. 3. The thickness of the formation is about 2 m in the eastern part of the Baltic Syneclise but in some places it reaches about 40 m. The total thickness of the Ordovician succession reaches in places 100 m.



BIOSTRATIGRAPHY AND CORRELATION

The oldest Ordovician deposits were encountered in boreholes of the marine sections of the Baltic Basin (Fig. 1; MODLIŃSKI *et al.* 1994). These are Tremadoc black claystones of the uppermost part of the Piaśnica Formation (HEINSALU and BEDNARCZYK 1997), most of which belongs to the Upper Cambrian succession (BEDNARCZYK 1979, 1994b). The Tremadoc strata contain an assemblage of the conodonts (*Cordylodus*; see LENDZION 1983), graptolites (*Rhabdinopora flabelliforme* s.l.), and brachiopods (*Obolus* cf. *apollinis*, see MODLIŃSKI 1991).

In the continental area of the Baltic Syneclise (the Łeba and partly the Gdańsk area), the Ordovician starts with the Gardno Formation. On the basis of an abundant conodont fauna (Table 1, Pl. 1: 1, 2, 21) from the Białogóra 1 and Gdańsk IG 1 drill cores, these beds are assigned to the upper Tremadoc (the *Paltodus deltifer* and lower part of *Paroistodus proteus* zones, Fig. 3). In other drillholes of this area (i.e. Dębki 2, Piaśnica 2, see BEDNARCZYK 1979), the Ordovician begins with the Słuchowo Formation, which on the basis of graptolites was correlated with the *Tetragraptus phyllograptoides* to *Phyllograptus angustifolius elongatus* zones. In carbonate intercalations of this formation, conodonts of the *Paroistodus proteus* to *Paroistodus originalis* zones were found (Table 1, Pl. 1: 3–8, 16, 18, 20, 23–25; see also BEDNARCZYK 1979).

In the other part of the Baltic Syneclise, the Ordovician begins with the Klewno or, in places, with the Pieszkowo (Łankiejmy Mb) Formations (Fig. 3). The assemblage of conodonts (Table 1), found within Klewno Formation permits the recognition of the *Prioniodus elegans–Oepikodus evae* or *Baltoniodus navis* zones (BEDNARCZYK 1989). Within the Łeba area, the Kopalino Member of the Pieszkowo Formation overlies the Słuchowo Formation (Fig. 3).

Fig. 2

Geophysical correlation of the Ordovician formations with the occurrences of conodont communities in the selected boreholes in the Polish part of the Baltic syneclise. Compiled on the basis of data from BEDNARCZYK (1968b, 1979, Białogóra 1 and Klewno 1 boreholes) and MODLIŃSKI (1982, Gdańsk IG 1 and Bartoszyce IG 1 boreholes). Abbreviations: 1 – sandstone, 2 – glauconitite or glauconitic sandstone, 3 – claystone, 4 – mudstone (of the Kokoszki Member), 5 – marly limestone, 6 – nodular limestone, 7 – limestone, 8 – nodular limestone with conglomerate at the bottom, 9 – boundary between formations, 10 – boundary between members, 11 – discountinuity surface, 12 – *Drepanodus–Paroistodus* Community, CAI 3–5, 13 – *Protopanderodus–Paroistodus* Community, CAI – 1–2, 14 – *Baltoniodus–Drepanoistodus* Community, CAI 1–2, 15 – *Baltoniodus–Dapsilodus* Community, CAI 1–2, 16 – *Drepanoistodus–Protopanderodus* Community, CAI – 3–5, 17 – *Scabbardella–Amorphognathus–Hamarodus* Community, CAI 1–2, 17 – *Hamarodus–Scabbardella* Community, CAI 1–2, C1+2 – Lower + Middle Cambrian, C3 – Upper Cambrian, Silurian, 75.3 m – thickness in meters.

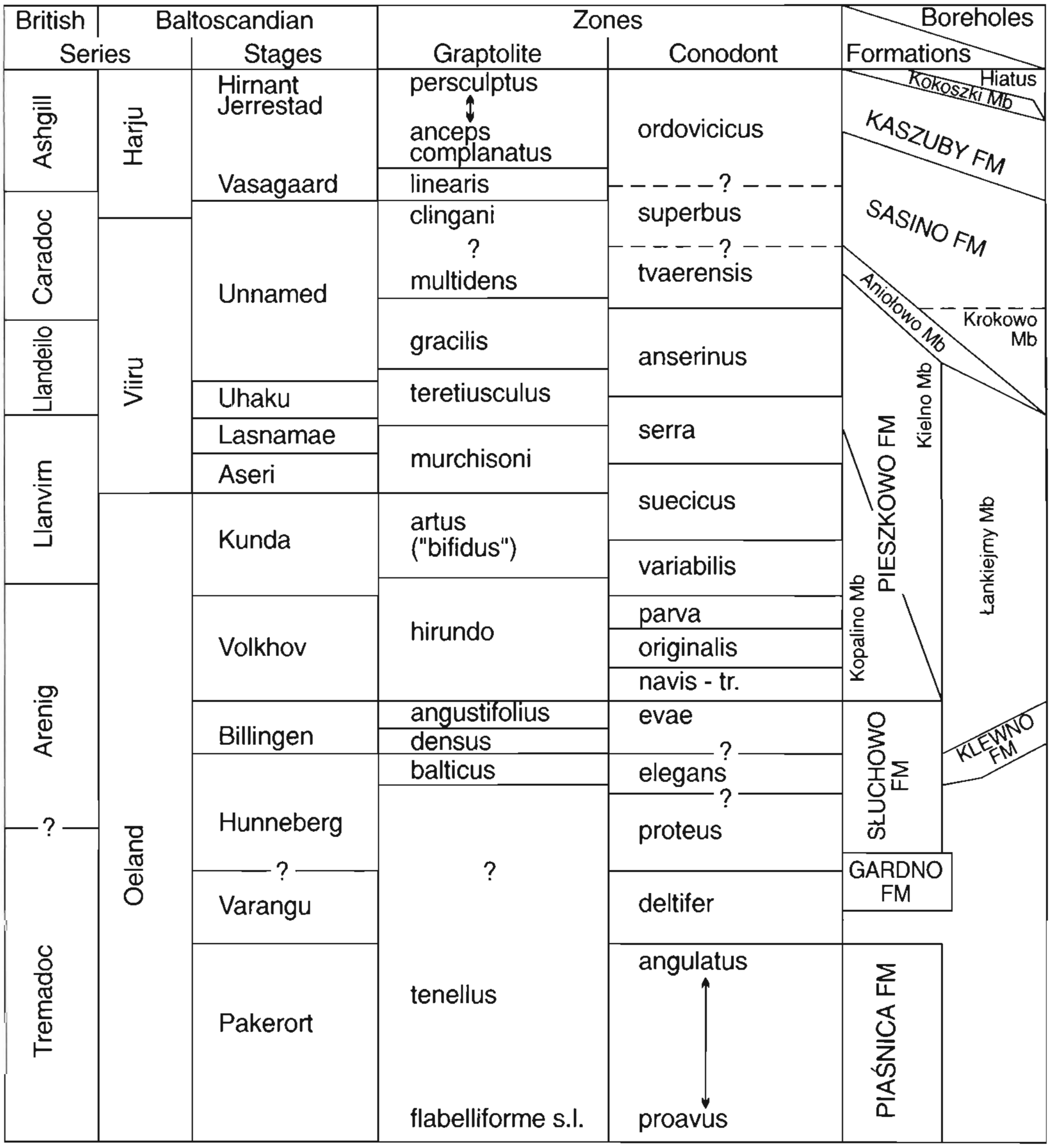


Fig. 3

Correlation of the bio- and lithostratigraphical divisions of the Ordovician in the Polish part of the Baltic syneclise. Graptolite and conodont zonation from BEDNARCZYK (1979, 1995), LENDZION (1983), and PODHALAŃSKA (1980). British and Balto-scandian series and stages compiled from JAANUSSON (1982), MALETZ *et al.* (1996), and FORTEY (1995).

On the basis of conodonts, it is possible to distinguish equivalents of the *Baltoniodus navis* and *Pygodus serra* zones (Table 1, Fig. 3, see also BEDNARCZYK 1979, PODHALAŃSKA 1980). In other parts of the Baltic Syneclise (the Łankiejmy Member of the Pieszkowo Formation), the present author (Table 1 and Pl. 1: 9–15, 19, 22, Pl. 2: 1–7, 9–12, 14–16) established the presence of the *Oepikodus evae* or the *Baltoniodus navis* (Billingenian to Volkhovian) zones at the base of the member. The top of the member ends with the *Microzarkodina ozarkodella* Subzone of the *Amorphognatus variabilis* Zone or, in places, with the *Pygodus anserinus* Zone or the *Eoplacognathus lindstroemi* Subzone of the *Pygodus serra* Zone (Fig. 3). It is worth noting that between the *Eoplacognathus robustus* Subzone and *E. suecicus* Zone a gap has been previously recognized (see BIERNAT and BEDNARCZYK 1990). Similarly, in the western part of the Syneclise, the presence of a gap in the Llanvirn sequence was suggested by PODHALAŃSKA (1980). The succeeding Kielno Member contains conodont fauna (e.g. Table 1 and Pl. 2: 8) of the *Amorphognathus variabilis* to the *A. tvarenesis* zones (Fig. 3). The Aniołowo Member is the uppermost unit within the Pieszkowo Formation. On the basis of conodonts (Table 1) this unit is assigned to the *Pygodus anserinus* and the *Amorphognathus tvaerensis* zones (Fig. 3).

Table 1
Conodont occurence in the Ordovician formations in the Polish part of the Baltic Syneclise.

Lithostratigraphy, boreholes, depths	Gardno Fm		Słuchowo Fm		Klewno Fm			Pieszkowo Formation														Sasino Fm		
								Kopalino Mb				Łankiejmy Mb				Kielno Mb			Aniołowo Mb				
	Białogóra 1 (2702.0–2700.0 m)	Gdańsk IG (3137.3–3135.4 m)	Białogóra 1 (2700.0–2689.0 m)	Dębki 2 (2660.3–2652.9 m)	Łaniewo 1 (1981.6–1979.8 m)	Łankiejmy 1 (1544.5–1544.0 m)	Klewno 1 (1540.0–1537.5 m)	Białogóra 1 (2689.0–2677.0 m)	Dębki 2 (2652.3–2641.3 m)	Dębki 3 (2667.6–2649.2 m)	Piaśnica 2 (2668.0–2648.6 m)	Henrykowo 1 (2463.3–2433.9 m)	Łaniewo 1 (1979.8–1963.6 m)	Łankiejmy 1 (1544.0–1524.0 m)	Klewno 1 (1537.5–1521.8 m)	Henrykowo 1 (2433.0–2407.3 m)	Łaniewo 1 (1963.6–1942.6 m)	Klewno 1 (1521.5–1509.7 m)	Łaniewo 1 (1942.6–1936.4 m)	Łankiejmy 1 (1524.0–1515.9 m)	Henrykowo 1 (2384.0–2368.8 m)	Łaniewo 1 (1936.4–1930.1 m)	Klewno 1 (1509.7–1499.5 m)
Westergaardodina fecheri	•																						
W. gediki	•																						
Coelocerodontus primitivus	•																						
C. variabilis						•																	
Cordylodus angulatus	•																						
Amorphognathus superbus												•											
A. tvaerensis																			•		•	•	•
A. variabilis													•	•	•								
Baltoniodus deltatus deltatus				•																			
Baltodus deltatus?	•																						
B. navis					•		•																
B. prevariabilis medius											•						•	•					
B. p. prevariabilis												•					•	•			•	•	•
B. cf. *p. norrlandicus*												•	•										
B. triangularis													•	•									
B. cf. *variabilis*												•									•	•	•
Cornuodus longibasis	•			•	•		•	•		•			•	•		•	•	•					
Scabbardella altipes																					•	•	•
Complexodus pugionifer																			•				
Dapsilodus mutatus																•	•	•	•	•	•	•	•
Strachanognathus parvus																					•		
Drepanodus arcuatus	•	•		•	•	•	•	•	•	•	•		•	•									
Drepanoistodus forceps			•		•	•	•		•	•	•		•	•		•		•					
D. basiovalis					•		•				•		•										
D. cf. *forceps*		•																					
D. inconstans?							•																
D. cf. *suberectus*																•							
Eoplacognathus elongatus																					•	•	•
E. lindstroemi												•									•		
E. reclinatus												•			•								
E. robustus																•	•				•		
E. suecicus											•	•											
E. zgierzensis												•											
Erraticodon balticus												•											
Gothodus costulatus				•	•																		
Hamarodus europaeus																					•	•	
Icriodella cf. *prominens*																					•		
Microzarkodella flabellum					•							•	•			•	•						
M. ozarkodella												•				•	•						
Oelandodus costatus													•	•									
Oepikodus evae					•				•														
O. cf. *intermedius*				•																			
Oistodus lanceolatus					•							•	•	•									

Lithostratigraphy, boreholes, depths	Gardno Fm		Słucho-wo Fm		Klewno Fm			Pieszkowo Formation													Sasino Fm		
								Kopalino Mb				Łankiejmy Mb				Kielno Mb			Aniołowo Mb				
	Białogóra 1 (2702.0–2700.0 m)	Gdańsk IG (3137.3–3135.4 m)	Białogóra 1 (2700.0–2689.0 m)	Dębki 2 (2660.3–2652.9 m)	Łaniewo 1 (1981.6–1979.8 m)	Łankiejmy 1 (1544.5–1544.0 m)	Klewno 1 (1540.0–1537.5 m)	Białogóra 1 (2689.0–2677.0 m)	Dębki 2 (2652.3–2641.3 m)	Dębki 3 (2667.6–2649.2 m)	Piaśnica 2 (2668.0–2648.6 m)	Henrykowo 1 (2463.3–2433.9 m)	Łaniewo 1 (1979.8–1963.6 m)	Łankiejmy 1 (1544.0–1524.0 m)	Klewno 1 (1537.5–1521.8 m)	Henrykowo 1 (2433.0–2407.3 m)	Łaniewo 1 (1963.6–1942.6 m)	Klewno 1 (1521.5–1509.7 m)	Łaniewo 1 (1942.6–1936.4 m)	Łankiejmy 1 (1524.0–1515.9 m)	Henrykowo 1 (2384.0–2368.8 m)	Łaniewo 1 (1936.4–1930.1 m)	Klewno 1 (1509.7–1499.5 m)
Paltodus deltifer	•	•																					
P. cf. *deltifer*		•																					
P. inconstans													•	•									
P. peracutus	•	•																					
P. cf. *subaequalis*	•		•	•																			
Panderodus gracilis																•	•				•	•	•
Paroistodus numarcuatus	•	•																					
P. originalis			•	•								•	•	•	•								
P. parallellus	•			•	•	•	•		•	•			•	•									
P. proteus		•		•					•														
Periodon aculeatus											•		•										
Plectodina cf. *tenuis*																					•	•	•
Polonodus sp.												•											
Protopanderodus liripipus																					•		
P. parvibasis													•		•								
P. rectus						•	•			•	•		•		•	•	•	•					
P. robustus											•		•						•	•	•	•	•
Prioniodus elegans?													•	•	•								
Pygodus anserinus												•				•	•		•		•	•	
P. serra																•				•	•		
Sagittodontina cf. *furcata*												•											
S. sp.												•											
Scalpellodus gracilis													•	•									
S. latus											•												
Scolopodus cornuformis													•	•	•								
S. peselephantis	•			•																			
S. rex					•	•	•						•	•	•								
Stolodus stola				•	•								•										
Walliserodus ethingtoni																•	•		•	•			
W. cf. *ethingtoni*												•											
W. nakholmensis																					•	•	

The succeeding Sasino Formation ranges from the Caradoc to the Ashgill (Fig. 3). In the eastern part of the Baltic Syneclise, within limestone intercalations, the present author has found an assemblage of conodonts characteristic of the *Pygodus serra* to the *Amorphognathus superbus* zones (Table 1).

The overlying Kaszuby Formation corresponds to the Ashgill Series and, in some cases, to the Llandeilo and/or Caradoc Series (Fig. 3). Its fauna consists mainly of trilobites and graptolites (BEDNARCZYK 1968; PODHALAŃSKA 1980; MODLIŃSKI 1982). An assemblage of conodonts from the upper part of the formation, (e.g. from the Rodnowo 1 section, depth 1931.0–1921.0 m, Fig. 1) includes *Aphelognathus* cf. *nudus* ORCHARD, *A. furcatus* (HINDE), *Besselodus* cf. *arcticus* ALDRIDGE, *Dapsilodus mutatus* (BRANSON *et* MEHL), *Icriodella* cf. *prominens* ORCHARD, *Protopanderodus liripipus* KENNEDY, *Plectodina* cf. *tenuis* (BRANSON *et* MEHL), *Scabbardella altipes* (HENNINGSMOEN) and, thus, suggests the *Amorphognathus ordovicicus* Zone (Fig. 3).

FINAL REMARKS

In the Ordovician, the northern and central Poland made up the southern part of the Baltic Basin (Fig. 1; BEDNARCZYK 1968b). To the north-west, this marine epicontinental basin bordered the Caledonian deformation zone of Scandinavia. Its western boundary is unclear because Ordovician deposits are not preserved at the Jutland peninsula in Denmark (JAANUSSON 1976). In the south-west, the Trans-European Fault separates the East-European Craton from the Baltic Basin and the Rügen–Koszalin–Chojnice Zone (the Marginal Thrust Belt, BERTHELSEN 1993; the Pomerania Terrane, POŻARYSKI *et al.* 1992; FRANKE 1994), which are tectonically and depositionally different (BEDNARCZYK 1974). In the southeast (Fig. 1), the Baltic Basin extended to the southern part of the Holy Cross Mountains (the Małopolska Massif(?) Proximal Terrane, DADLEZ *et al.* 1994).

The Ordovician deposits of the Balto-Scandian type occur also farther southeast in Volhynia, Podolia and Mołdova (ZINOVENKO 1986). To the east, the Baltic Basin reached the Moscow Basin (MÄNNIL 1966).

Within the Balto-Scandian part of this basin, JAANUSSON (1976) distinguished several facies zones e.g. the Scanian, Central Balto-Scandian confacies belts, etc. The majority of Poland was occupied by the coexisting red and grey carbonate facies comparable to the Swedish-Latvian facies zone (BEDNARCZYK 1968b) and the Central Balto-Scandian confacies belt (BEDNARCZYK 1979).

The Conodont elements discussed here permit to recognize several Conodont communities through time. In the north-eastern part of Poland (e.g. the Klewno 1 section, Fig. 2), the facies equivalent of the Łankiejmy Member is characterized by frequent elements of *Baltoniodus* and *Drepanoistodus* genera. In the central part of the area (e.g. the Łaniewo 1 section, Fig. 1), more frequent are elements of *Drepanoistodus* and *Protopanderodus*.

Almost everywhere in the Polish part of the Baltic Basin, except of the Łeba area, cherry-brown nodular limestones of the Łankiejmy Member of the Pieszkowo Formation overlie, grey-greenish biomicritic limestones with dispersed grains of glauconite and grains of quartz and chamosite ooliths of the sandy Klewno Formation which, in turn, transgressively cover various members of the Middle and Uppermost Cambrian sandstones containing valves of *Ungula ingrica* EICHWALD and *Ungula convexa* PANDER (BEDNARCZYK 1989, 1994a). The deposits of the Klewno Formation are characterized by frequent elements of *Protopanderodus* and *Paroistodus* in the eastern part of the basin, and by frequent elements of *Drepanoistodus* and *Paroistodus* in its central part (Figs 1, 2).

The Łankiejmy Member may be related to the Latorp and Lanna Limestone of Sweden (JAANUSSON 1982). It grades upward and laterally into the marly limestone of the Kielno Member and in places into the oolitic limestone of the Aniołowo Member. Similarly, to the Łankiejmy Member, the Kielno Member is characterized by frequent elements of *Baltoniodus*. The elements of *Dapsilodus* are also numerous (Fig. 2). In contrast, the Aniołowo Member is characterized by frequent elements of *Scabbardella*.

In the southern part of the Scanian – Łeba confacies belt, the Upper Cambrian black ferrugineous claystones of the Piaśnica Formation grade upwards into the Lower Tremadoc marly claystones (MODLIŃSKI *et al.* 1994). However, in the Łeba area, the Ordovician begins with the Upper Tremadoc marly, strongly bituminous claystone of the Gardno Formation with intercalations of glauconitite and glauconitic limestone (BEDNARCZYK 1979; HEINSALU and BEDNARCZYK 1997). The boundary between these two formations is a glauconite lamina (see the Białogóra 1 column in BEDNARCZYK 1979). However, a little farther eastward in the Gdańsk Depression (the Gdańsk IG 1 section), the Gardno Formation is separated from the Upper Cambrian (*Peltura scarabaeoides* Zone) by a thin conglomerate consisting of sandstone pebbles.

Lithofacially and stratigraphically, the Gardno Formation corresponds to the *Ceratopyge* (Björkasholmen) Limestone of South Öland (compare ERDTMANN 1995). The deposits of this formation are characterized by frequent elements of *Drepanodus* and *Paroistodus* (Fig. 2). The limestone of the Gardno Formation gradually grades upwards into the Słuchowo Formation, which consists of grey-green marly claystones with glauconite laminae and grey-brownish claystones with scattered glauconite grains and with carbonate intercalations in which conodonts *Drepanodus, Paroistodus* and *Drepanoistodus* (Fig. 2) are common.

The Słuchowo Formation can be regarded a southern extension of the Tøyen Shale of Scandinavia (BERGSTRÖM 1982; MALETZ *et al.* 1996). Grey-beige to dark-grey or grey-green marly limestones with scattered glauconite grains, intercalated with black claystone and veins or nests of calcite of the Kopalino

Member of the Pieszkowo Formation, overlie the deposits of the Słuchowo Formation. The elements of *Drepanoistodus* and *Protopanderodus* are very common in this succession (Fig. 2).

The Kopalino Member may be considered a western tongue of the Pieszkowo Formation between the Słuchowo Formation and the Sasino Formation. A similar model of sedimentation was presented by JAANUSSON (1982) for the Swedish part of the Baltic Basin where the Komstad Formation occurs between the Tøyen Formation and the Upper *Didymograptus* Shale (BERGSTRÖM 1982).

The Kopalino Member and its equivalents in the Pieszkowo Formation are succeeded by the Sasino Formation in the whole area under discussion. In places, these claystones contain thin interbeds of grey limestone. Numerous bentonite and tuffitic intercalations also occur within this succession (PRZYBYŁOWICZ 1980). The elements of *Scabbardella* and *Amorphognathus* and *Hamarodus* are very common (Fig. 2).

The facies equivalent of the Sasino Formation may be the clayey complex of the Upper *Didymograptus* and *Dicellograptus* shales in Scania (BERGSTRÖM 1982). In the other part of the area under discussion the Sasino Formation is represented by grey or dark-grey claystone with organodetritic laminations. In the Łeba area, the Sasino Formation is succeeded by marls and marly limestones of the Kaszuby Formation. The deposits contain an admixture of terrigeonus material consisting of grains of quartz and feldspar. Locally, the topmost part of the formation is the sandy limestone of the Kokoszki Member. In the other part of the Baltic Basin, the Kaszuby Formation begins with rust-colored, brown or red-brown limestones or claystones. In Västergötland such red deposits represent the mudstones of the Jonstorp Formation (JAANUSSON 1982). These red deposits are replaced by grey micritic, in places seminodular, limestones with dispersed quartz grains and nests and concentrations of pyrite. The facies is characterized by frequent *Hamarodus* and *Scabbardela* elements (Fig. 2). Locally, stratigraphic gaps end the sedimentation of the Ordovician in the Polish part of the Baltic Basin (BEDNARCZYK 1968b).

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CONODONT STRATIGRAPHY OF THE ORDOVICIAN FORMATIONS

PLATE 1

Paltodus deltifer (LINDSTRÖM, 1955)

1. Drepanodontiform element, WB100, Białogóra 1, 2701.4–2702.0 m, × 150.
21. Oistodontiform element, WB101, Gdańsk IG 1, 3135.4–3137.3 m, × 150. Samples from the Gardno Fm.

Paroistodus numarcuatus (LINDSTRÖM, 1955)

2. Drepanodontiform element (WB102) from the Gardno Fm, Białogóra 1, 2701.4–2702.0 m, × 160.

Microzarkodella flabellum (LINDSTRÖM, 1955)

3. Oistodontiform element, WB103, 2423.5–2425.0 m, × 80.
8. Cordylodontiform element, 2423.5–2425.0 m, × 70.
16. Ozarkodiniform element, WB104, 2423.5–2425.0 m, × 80. All samples from the Łankiejmy Mb of the Pieszkowo Fm, Henrykowo 1.

Periodon flabellum (LINDSTRÖM, 1955)

4. Cordylodontiform element (WB105) from the Łankiejmy Mb of the Pieszkowo Fm, Henrykowo 1, 2424.5–2425.0 m, × 85.
7. Trichonodelliform element (WB106) from the Klewno Fm, Łaniewo 1, 1979.2 m, × 100.

Paroistodus originalis (SERGEEVA, 1963)

6. Oistodontiform element, WB107, 1979.2 m, × 110.
18. Drepanodontiform element,WB108, 1979.2 m, × 75. Samples from the Klewno Fm, Łaniewo 1.

Paroistodus parallelus (PANDER, 1956)

5. Oistodontiform element, WB109, 1979.2 m, × 70.
24. Drepanodontiform element,WB110, 1979.2 m, × 100. Samples from the Klewno Fm, Łaniewo 1.

Baltoniodus prevariabilis (FÅHRÆUS)

9. Paracordylodontiform element, WB111, 2419.2 m, × 120.
10. Ambalodontiform element, WB112, 2419.2 m, × 80.
12. Amorphognatiform element, WB113, 2423.5–2424.8 m, × 80.
13. Oistodontiform element, WB114, 2424.8–2425.0 m, × 130. Samples from the Łankiejmy Mb of the Pieszkowo Fm, Henrykowo 1.

Sagittodontina cf. *furcata* (KNÜPFER, 1967)

11. Ambalodontiform element (WB115) from the Łankiejmy Mb of the Pieszkowo Fm, Henrykowo 1, 2418.5, × 80.

Walliserodus cf. *ethingtoni* (FÅHRÆUS, 1966)

14. Trichonodelliform element (WB116) from the Łankiejmy Mb of the Pieszkowo Fm, Henrykowo 1, 2424.3 m, × 100.

Baltoniodus cf. *variabilis* (BERGSTRÖM, 1963)

15. Paracordylodontiform element, WB117, 2419.7 m, × 100.
19. Trichonodelliform element, WB118, 2421.5–2422.5 m, × 130.
22. Tetraprioniodontiform element, WB119, 2419.3 m, × 130. Samples from the Łankiejmy Mb of the Pieszkowo Fm, Henrykowo 1.

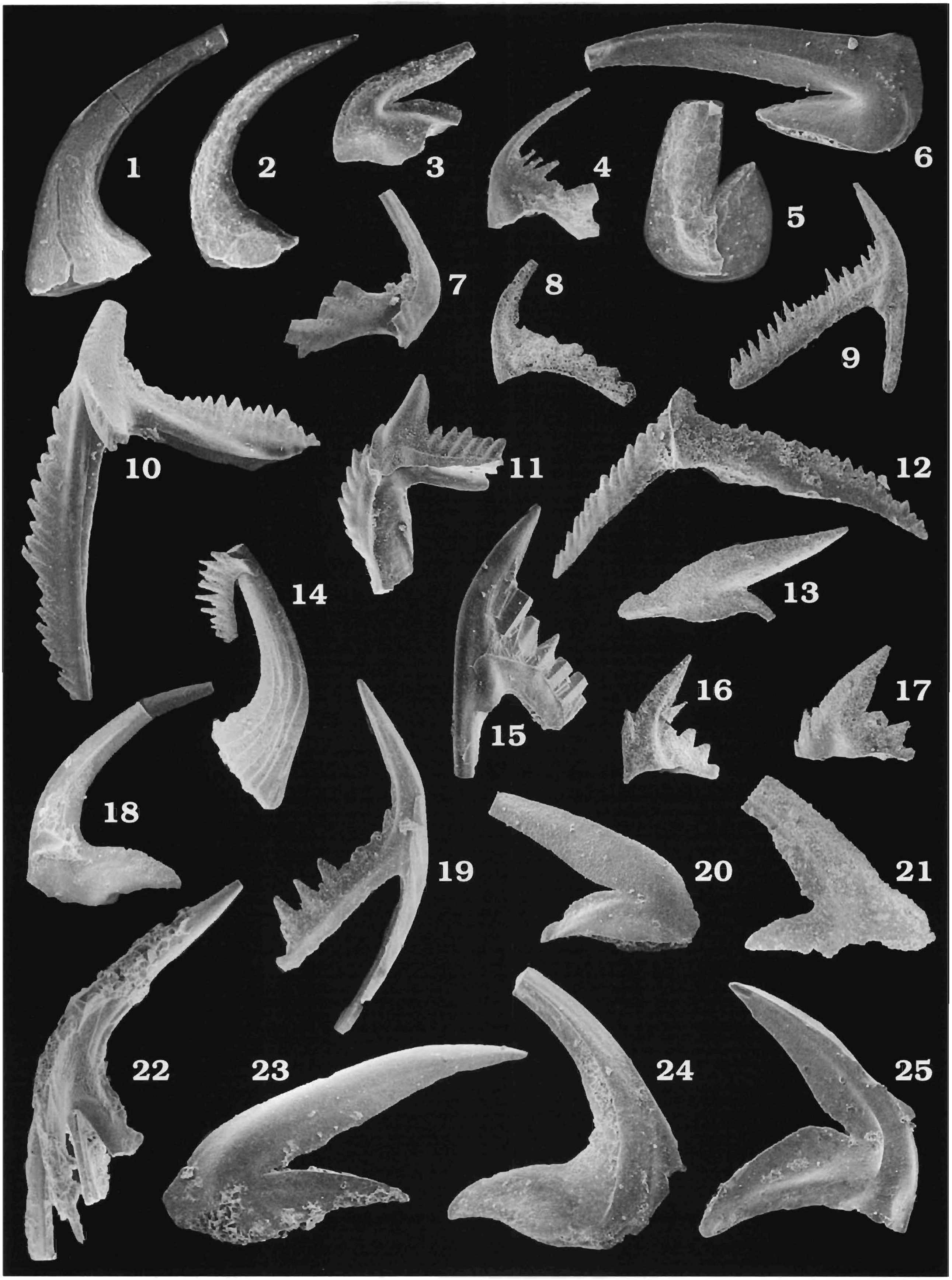
Oistodus lanceolatus PANDER, 1956

20. Oistodontiform element (WB120) from the Łankiejmy Mb of the Pieszkowo Fm, Henrykowo 1, 2421.5–2422.5 m, × 100.
23. Oistodontiform element (WB121) from the Klewno Fm, Łaniewo 1, 1979.8 m, × 110.
25. Trichonodelliform element, WB122, 1979.8–1980.0 m, × 150. Samples from the Klewno Fm, Łaniewo 1.

Microzarkodella ozarkodella LINDSTRÖM, 1971

17. Oistodontoform element (WB123) from the Łankiejmy Mb of the Pieszkowo Fm, Henrykowo 1, 2418.0–2420.2 m.

1, *2* and *21* represent elements from the Gardno Formation; *5–7*, *11*, *14*, *18*, *23–25* elements from the Klewno Formation; *3*, *4*, *8–10*, *12*, *13*, *15*, *17*, *19*, *20* elements from the Łankiejmy Member of the Pieszkowo Formation. Element in *16* from the Łaniewo 1 and element in *22* from the Henrykowo 1 boreholes.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CONODONT STRATIGRAPHY OF THE ORDOVICIAN FORMATIONS

PLATE 2

Eoplacognathus lindstroemi (HAMAR, 1964)

3. Amorphognathiform element, WB124, 2413.8 m.
5. Ambalodiform element, WB125, 2412.6 m, × 110.
6. Ambalodiform element, WB126, 412.7 m, × 110.
7. Amorphognatiform element, WB127, 2413.8 m, × 90.
10. Amorphognatiform element, WB128, 2413.8 m, × 120. Samples from the Łankiejmy Mb of the Pieszkowo Fm, Henrykowo 1.

Eoplacognathus reclinatus (FÅHRÆUS, 1966)

11. Amorphognatiform element (WB129) from the Łankiejmy Mb of the Pieszkowo Fm, Henrykowo 1, 2413.8 m, × 90.

Eoplacognathus suecicus BERGSTRÖM, 1971

9. Ambalodiform element (WB130) from the Łankiejmy Mb of the Pieszkowo Fm, Henrykowo 1, 2419.0 m, × 110.

Eoplacognathus zgierzensis (DZIK, 1976)

2. Ambalodiform element, WB131, 2413.5 m, × 180 from the Łankiejmy Mb of the Pieszkowo Fm, Henrykowo 1.

Eoplacognathus cf. *robustus* BERGSTRÖM, 1971

1. Amorphognathiform element, WB1132, 2410.6–2411.0 m, × 180.

Eoplacognathus cf. *lindstroemi* (HAMAR, 1964)

12. Amorphognatiform element (WB133) from the Łankiejmy Mb of the Pieszkowo Fm, Henrykowo 1, 2413.5 m, × 180.

Pygodus anserinus LAMONT *et* LINDSTRÖM, 1957

4. Haddingodiform element, WB134, 2413.2 m, × 120.
16. Pygodiform element, WB135, 2413.5 m, × 120. Samples from the Łankiejmy Mb of the Pieszkowo Fm, Henrykowo 1.

Amorphognathus superbus (RHODES, 1953)

8. Amorphognatiform element (WB136) from the Kielno Mb of the Pieszkowo Fm, Henrykowo 1, 2384.0 m, × 110.

Erraticodon balticus DZIK, 1978

13. Hindeodelliform element (WB137) from the Łankiejmy Mb of the Pieszkowo Fm, Henrykowo 1, 2411.2 m, × 100.

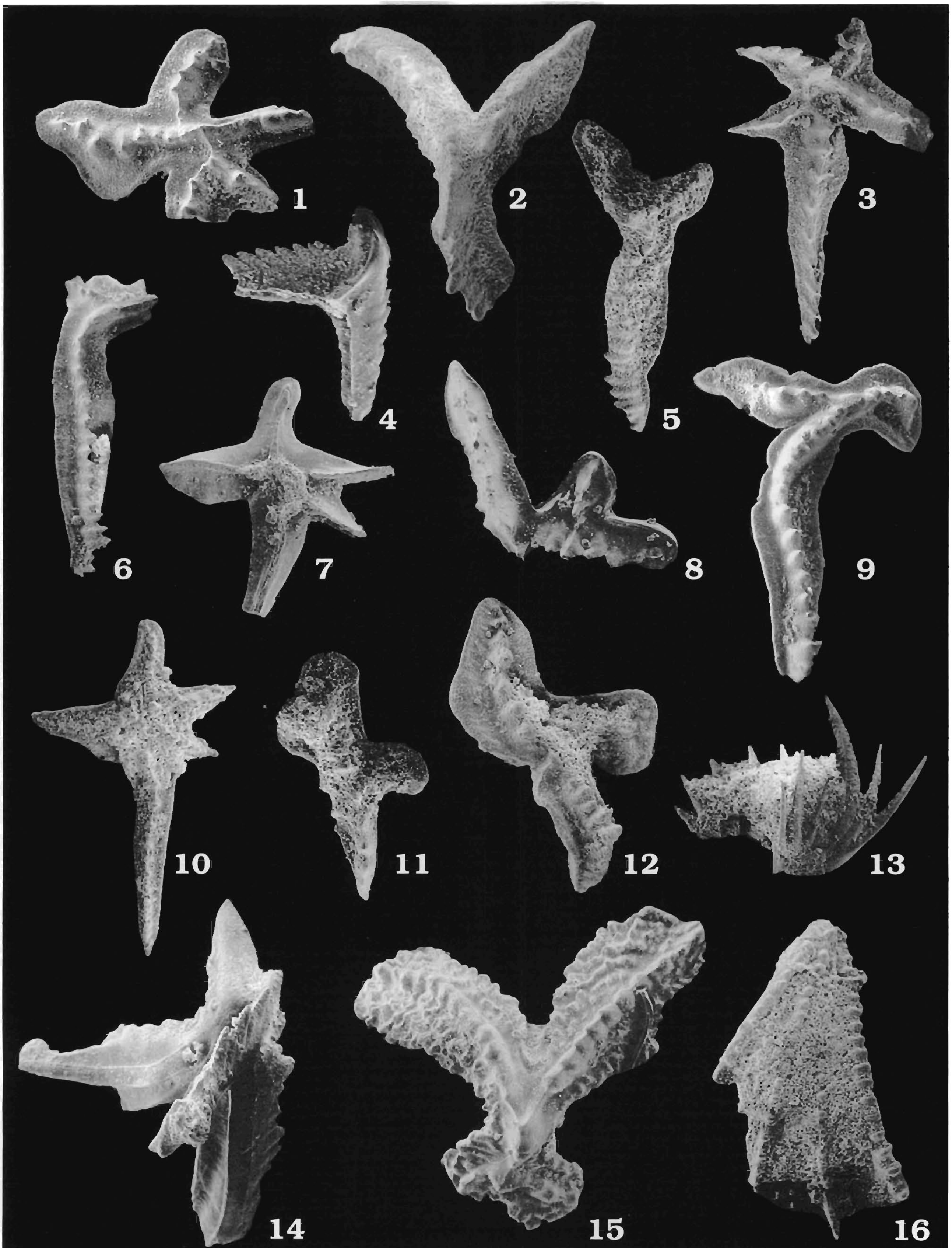
Polonodus sp.

15. Specimen (WB138) from the Łankiejmy Mb of the Pieszkowo Fm, Henrykowo 2, 2423 m, × 100.

Sagittodontina sp.

14. Specimen (WB139) from the Łankiejmy Mb of the Pieszkowo Fm, 2424.8 m, × 130.

All samples from the Henrykowo 1. *1–7*, *9–16* elements from the Łankiejmy Member of the Pieszkowo Formation; *8* element from the Kielno Member of the Pieszkowo Formation.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